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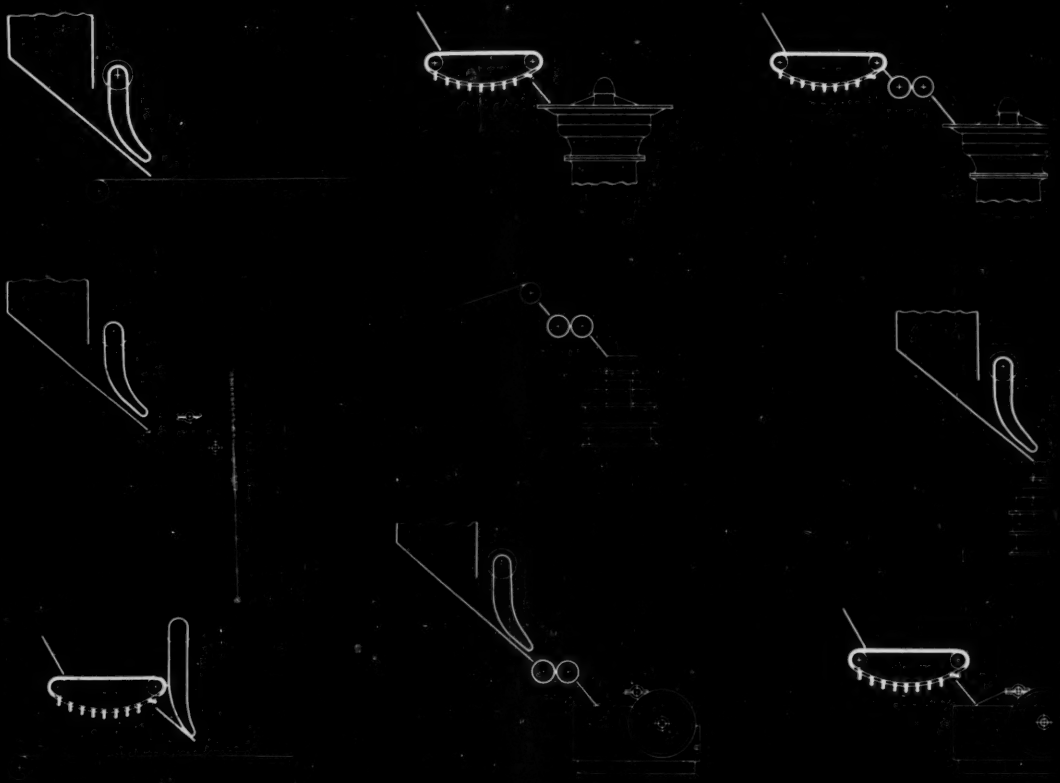

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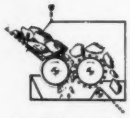

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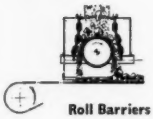

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EDITORIAL

A TWO-DAY national conference organized by the Department of Scientific and Industrial Research and to be held in Swansea in April is to discuss problems of communication in science and industry. In announcing this the Department points out that rapid communication is a vital link in modern technology and, when over £300,000,000 is spent each year on industrial research and development, it is a problem urgently demanding attention from industrial management. Research results must be made known quickly and clearly, it is thought, to the widest possible technical audience, while existing knowledge has to be used with benefit; the time lag between a scientific development and industrial application must, it is evident, be cut.

UNDER the auspices of the American Institute of Mining, Metallurgical, and Petroleum Engineers a First International Symposium on Agglomeration is to be held in Philadelphia next April. Those attending will hear 36 technical papers prepared by authors from the United States, Canada, Australia, South America, the United Kingdom, Germany, Sweden, and Japan. The programme, sponsored by the Institute and its three constituent organizations, the Society of Mining Engineers, the Metallurgical Society, and the Society of Petroleum Engineers, is considered outstanding in its scope. The overall theme is agglomeration in all its phases—sintering, pelletizing, nodulizing, briquetting, powder metallurgy, and other aspects—as related to ferrous and non-ferrous metallic and non-metallic materials.

AMONG recent visitors to Kalgoorlie was Dr. G. W. H. Schepers, of the McIntyre Research Foundation. Aluminium therapy has been practised on the Golden Mile mines for some years past and Dr. Schepers went, first, to see for himself the results of the treatment and, secondly, to advise the industry that the treatment be continued for at least another seven years. He said that "in American plants thousands of persons are being treated daily with aluminium therapy and there have been no proofs of any harmful effects"; rather that it contributes largely to the health of miners and was not harmful in any way to body tissues. Dr. Schepers expressed the opinion that it was too soon to stop the treatments now; it would be stopped at a very critical moment. He would prefer to see men (miners) encouraged to continue the treatments and any causes of complaint removed.

QUITE a number of names appear in the New Year Honours List that will be of interest to readers. The C.B.E. has been awarded to Professor J. C. Mitcheson, professor of mining in the University of London and Dean of the Royal School of Mines, to Dr. J. B. Alexander, Director of the Geological Survey, Federation of Malaya, and to Dr. F. T. Ingham, who was until recently Director of the Geological Survey of Cyprus. Others to receive this award are Mr. J. P. Feeny, Secretary of Lands and Mines, Nyasaland, and Mr. R. G. Newton, general manager, Broken Hill Proprietary Co. Lt.-Col. J. Cross Brown, formerly chairman of Mason and Barry, Ltd., receives the O.B.E., which is also awarded to Mr. E. G. V. Newman, Principal Scientific Officer, the Royal Mint, and Mr. F. R. J. Williams, Permanent Secretary, Ministry of Natural Resources, Uganda. Mr. F. J. Shute, H.M. Inspector of Mines and Quarries, South-West Division, Ministry of Power, receives the M.B.E.

THE results of a Survey [1] by the Department of Scientific and Industrial Research, in co-operation with the British Non-Ferrous Metals Research Association and the electro-plating industry, into the wastage of nickel and chromium salts has now been published. Under the title "A Survey of Nickel and Chromium Recovery in the

[1] Copies of the booklet can be obtained, free of charge, from the Library, Department of Scientific and Industrial Research, 5–11, Regent Street, London, S.W. 1.

Electro-plating Industry," it discusses promising lines of attack for the elimination of waste and the reduction of pollution.

Nickel and chromium salts are largely wasted in substantial amounts by " drag-out "—*i.e.*, when the solution is carried away by plated articles as they leave the bath, although spray formation is often a cause. Out of an estimated total weight of 2,870 tons of nickel used in 1958 about 290 tons represented the metal content of the nickel sulphate and chloride used, these chemicals increasing the total material cost by about 13%. Now, however, the use of a simple static rinse tank has been found to eliminate three-quarters of the cost of these salts, the installation of such a tank in a manually-operated plant being usually inexpensive. Reduction in water consumption by the use of counterflow rinses is also recommended. In addition, it is further concluded that there is potential value in the ion-exchange process for the purification and re-use of effluent solutions. This may yet give a promising alternative to present effluent treatment by chemical means.

British Overseas Mining Association

A year ago Mr. A. V. Conrad, then president of the British Overseas Mining Association, said that there were two amendments to the legislation relating to Overseas Trade Corporations which the Association would like to have revised. They hoped, he said, that Overseas Trade Corporations with subsidiaries resident abroad might be allowed to transmit dividends untouched to the parent company in order that they might be used to the best advantage. In addition it was urged that loans to associated companies should be treated for tax purposes in the same way as distributions to shareholders. Presiding at the annual general meeting of the Association last month Mr. Conrad's successor as president, Mr. J. N. V. Duncan, referred again to these matters, to which, he said, the Association attached the greatest urgency and in regard to which it had made very full representations to successive Chancellors of the Exchequer. In spite of this, however, the 1960 Budget did not meet any of the submissions made and the Association felt that it was no further forward. Mr. Duncan said that a year ago there was a strong case to support the proposals referred to but he thought that case now even stronger. In recent months, he said, events in many parts of the world—notably throughout Africa and in Cuba—had underlined the risks inherent in mining business overseas, where sequestration might mean a complete loss of assets. That had all happened at a time when governments and international bodies were urging the importance of developing under-developed territories and urging private enterprise to play its part.

Mr. Duncan thought the British mining industry might be justly proud of the rôle that it had played in developing the world's resources. There was, he said, hardly a country whose development had not been helped. The development of mineral resources still held the key to the future of many of the emergent nations and also offered a challenge to the free world. The importance of meeting that challenge had been constantly underlined and the British industry was well equipped to give a helping hand, having the experience necessary and highly trained staffs available. It also had at its disposal substantial financial resources without which no large-scale mineral development could be contemplated. The industry, however, was private enterprise employing shareholders' money and there could be no question as to the risks inherent in many of the most urgently needed developments. This country's taxation system did not make such action possible at present and unless it could be amended it would be difficult for the industry to go on playing its full and important part in developing the resources of the world.

Mr. Duncan said that this problem, the solution of which he believed was essential not only to the industry but for the country, was by far the most important one with which the Association was concerned and we would agree with him. During the past year it had occupied a great deal of the time of the members of the Association's Taxation Committee whose efforts, it can only be hoped, may yet succeed in impressing the Chancellor of the Exchequer.

The Outlook for Nickel

Last year Dr. John F. Thompson, then chairman of the board of directors of the International Nickel Co. of Canada, Ltd., issued his customary year-end review of the world nickel situation. This year his

successor in that position, Mr. Henry S. Wingate, continues the practice and makes some useful comments on likely trends in the industry. He points out that nickel producers continued to increase output capacities in 1960 and estimates that before the end of 1961 the total nickel production capacity of the free world, exclusive of Cuban sources, will approach 600,000,000 lb. annually, of which Canada will account for more than three-quarters. The new nickel project at Thompson, Manitoba, rapidly nearing completion, will contribute substantially to the anticipated increase in production, since it will have an annual capacity of fully 75,000,000 lb. of nickel, making it the second largest nickel production operation in the world after Inco's facilities in the Sudbury District of Ontario. With the Thompson project in full operation International Nickel's total annual capacity of nickel will be more than 385,000,000 lb., while the planned annual nickel production capacity of other Canadian producers will include 65,000,000 lb. or more from Falconbridge Nickel Mines and about 25,000,000 lb. from Sherritt Gordon Mines. Elsewhere the planned capacity of the French nickel company, Societe Le Nickel, in New Caledonia, has been estimated at about 55,000,000 lb., while nickel production capacity in the United States, mainly from the plants of the Hanna Mining Company in Riddle, Oregon, remains at approximately 23,000,000 lb. per year. The balance of the free world's nickel production capacity consists largely of that of Japanese refiners employing imported ores. Such refiners could support, Mr. Wingate suggests, if sufficient ore is available, an annual production of 35,000,000 lb. of nickel. Because of political developments in Cuba, he says, the figures given do not include the planned outputs, totalling about 100,000,000 lb., of the plant built by the United States Government at Nicaro or the facilities built by Freeport Sulphur. It is not possible, he thinks, to predict how soon there will be a resumption of nickel supply for the free world from these sources.

Last year the consumption of nickel by the free world set a new high annual record, exceeding 500,000,000 lb., an increase of over 15% above that of 1959. A substantial increase in the use of nickel in Europe, Mr. Wingate said, was the main contributing factor to the record-breaking figure, consumption in North America, for many years the world's largest market for nickel, being below that of the balance of the free world. In 1960 it is thought the consumption of nickel in the United States and Canada will be approximately the same as in the previous year, large inventory liquidations by consumers of steel products holding back production of stainless and alloy steels during the second half of the year. For 1960, Mr. Wingate said, the geographical distribution of the free world's consumption of nickel by areas was estimated to be as follows: Europe, 43·5%; United States, 43%; Canada, 2·5%, and others, 11%.

United States Mineral Output

Preliminary figures issued by the United States Bureau of Mines state that the value of the mineral output in that country in 1960 reached an estimated $17,800,000,000, some 4% above the 1959 figure and second only to the record of $18,100,000,000 established in 1957. Metals, affected in 1959 by prolonged strikes at many mines, were higher by an estimated 28% in 1960, non-metallics gaining 2%, and the increased value of fuels more than offsetting the drop in value of other non-metallics.

Those metals whose output was affected by strikes in the last half of 1959 and the first quarter of 1960—copper, iron, vanadium, and tungsten—all reported increases ranging from 30% to 40% for 1960, thus counterbalancing declines in lead, zinc, silver, manganese, rare earths, and thorium. The uranium output was increased from $141,000,000 to $156,000,000 and small increases were registered by gold and platinum. Interest continued in the semi-conductor materials—silicon, germanium, and tellurium—although production and consumption of selenium dropped sharply.

The values of fuels were mixed, with increases reported for natural gas, natural-gas liquids, helium, peat, and petroleum, while values of anthracite and bituminous-coal output were smaller. There was also a slackening demand for materials of construction—cement, clays, gypsum, and stone—mainly in residential building, which was only partly offset by increased demand for chemical and fertilizer materials. The result was a 2% drop in total worth of non-metallics other than fuels.

MONTHLY REVIEW

Introduction.—Latest Government pronouncements show that there is still fear of inflation and a continued determination that, until the danger is considered less, credit restrictions must remain in force. Generally speaking it is inferred that the country's living standards are well worth preserving.

Transvaal.—The gold return figures for the Rand and O.F.S. mines for November show a production of 1,775,624 oz., making with 36,159 oz. from outside mines a total of 1,811,783 oz. for the month, a new record. The number of natives at work in the gold mines at the end of November was 367,658, as compared with 368,391 at October 30 last.

The table below shows dividends declared by the Rand mining companies for the past half-year. Figures for the three preceding half-years are added for comparison, the denominations of shares being £1 unless otherwise stated.

	1st half, 1959	2nd half, 1959	1st half, 1960	2nd half, 1960
	s. d.	s. d.	s. d.	s. d.
Blyvooruitzicht (2s. 6d.)	1 1	1 2	1 3	1 3·6
Brakpan (5s.)*	0 4½	0 6	0 4½	0 6
Buffelsfontein (10s.)	1 6	1 9	1 10½	1 9
City Deep	0 7½	0 7½	0 7½	0 8·4
Consolidated Main Reef	1 6	1 3	1 6	1 6
Consolidated Murchison (5s.)	2 9	5 6	3 6	4 3
Crown Mines (10s.)	1 9	2 0	2 0	2 0
Daggafontein (5s.)	2 3	2 3	2 0	2 0
Dominion Reefs (5s.)	1 6	1 6	1 6	1 3
Doornfontein (10s.)	1 6	1 6	1 6	1 4·8
Durban R'dpoort D'p (10s.)	1 6	1 6	1 6	1 6
East Champ d'Or (2s. 6d.)	0 3	0 3	0 3	0 3
East Daggafontein (10s.)	0 7½	0 7½	0 7½	0 9
East Geduld (4s.)	1 9	1 11	1 8	1 9·6
East Rand Prop. (10s.)	1 9	1 9	1 9	1 6
Eastern Rand Ext. (5s.)	0 9	1 0	0 9	1 0
Eastern Transvaal Consol. (5s.)	0 3	0 1½	0 3	—
Geduld Prop.	4 9	5 0	3 4	3 7·2
Government Areas (3d.)*	—	—	—	0 3
Grootvlei Prop. (5s.)	1 1	1 5	1 1	1 4·8
Hartebeestfontein (10s.)	3 6	3 0	3 0	2 6
Libanon (10s.)	0 3½	0 3½	0 4½	0 4·8
Luipaards Vlei (2s.)	1 0	1 0	1 0	1 0
Marievale Consolidated (10s.)	1 4	1 7	1 6	1 10·8
Middle Wits (2s. 6d.)	0 7½	0 7½	0 7½	0 7·5
Modderfontein B. (3d.)	—	0 6	—	0 6
Modderfontein East	0 6	1 0	0 6	0 6
New Klerksdorp (5s.)	1 0	1 0	1 3	1 7
New Pioneer Central Rand (5s)	2 9	1 3	1 9	1 6
Rand Leases (3d.)*	—	1 0	—	—
Randfontein	1 9	2 3	1 3	1 9
Rietfontein Cons. (3d.)*	—	0 8	0 6	0 7·2
Rose Deep (3d.)	—	—	—	1 0
South African Land (3s. 6d.)	1 3	0 6	0 6	0 6
South Roodepoort M.R. (10s.)	1 1½	1 1½	1 1½	1 1·5
Southern Van Ryn	—	0 7	—	0 7·2
Springs Mines (5d.)*	—	0 6	—	0 6
Stilfontein (5s.)	1 10½	1 7½	1 6	1 6
Sub Nigel (3d.)*	—	1 3	1 3	1 3
Vaal Reefs (5s.)	1 6	2 0	1 6	2 0
Venterspost (10s.)	0 10½	0 10½	1 0	1 0
Vlakfontein (10s.)	0 11	1 0	0 11	1 1·2
Vogelstruisbult (3d.)*	—	0 10	0 8	0 8·4
West Driefontein (10s.)	4 3	4 9	2 7½	2 10·8
West Rand, Ord. (10s.)	2 0	2 3	2 0	2 3
Western Reefs (5s.)	1 3	1 3	1 3	1 3
Witwatersrand Nigel (2s. 6d.)	0 1½	—	0 1½	—

* Capital Repayment.

With the dividend notices issued by the Rand mining groups last month shareholders were reminded that in terms of the Decimal Coinage Act, 1959, of the Union of South Africa decimal coinage is to be adopted in the Union with effect from February 14. Payments to follow that date will be paid in the new currency, which accounts for the new look of the figures in shillings and pence.

Shareholders of WESTERN DEEP LEVELS have been informed that the Ventersdorp Contact Reef was intersected in the No. 3 Ventilation Shaft at 6,413 ft. below collar, dipping in a northerly direction at 13°. The reef, sampled at intervals of 5 ft. around the perimeter of the shaft, gave average values of 11·86 dwt. a ton over a channel width of 34·73 in.

At the end of December ZANDPAN GOLD MINING gave complete results from Borehole T.L. 45, situated 4,800 ft. west of No. 1 shaft. The Vaal Reef, originally cut at 6,608 ft. and going 0·72 dwt. over 5·9 in., gave 2·16 dwt. over 11 in. in the first deflection at 6,607 ft. and 7·3 dwt. over 10 in. in the second at 6,606 ft. The leader reef cut at 6,599 ft. and assaying 8·13 dwt. over 40·6 in. gave 9·26 dwt. over 42 in. at 6,598 ft. in a first deflection and 10·73 dwt. over 41 in. at 6,598 ft. in the second.

BRACKEN MINES recently announced that the No. 1 shaft had intersected the reef at 2,363 ft. below the collar and that sampling around the whole perimeter gave 22·7 dwt. over 23 in.

It can be noted from the speech of the chairman at the recent annual meeting of HARTEBEESTFONTEIN GOLD MINING that the amount of ore drawn from the deeper area has now been increased to 45% of the total milled and that hoisting from a greater depth has increased working costs. In addition, owing to the major fault which traverses the lease area and the resulting disposition of the reef, it has so far been necessary to sink four main shafts and one small ventilation shaft. A further shaft system will be required in the north-western portion of the mine and it is expected that a shaft to serve this area will be commenced in 1965.

Development results at WINKELHAAK MINES in the three months to December 31 showed little change from those obtained in the previous quarter, but the ore reserve is now 2,700,000 tons. In the No. 2 Shaft area pre-cementation continued and a second

surface bore-hole is being drilled to help with this work. Preliminary sinking of the shaft has commenced and at the end of the quarter a depth of 45 ft. had been reached. Good progress has been made with the foundations for the winding engines and the winding engine house, it is stated, while the change-house and shaft offices are under construction.

The accounts of WITBANK COLLIERY for the year ended August 31 last show a profit of £303,238 and a total of £616,695 available, of which dividends equal to 2s. 6d. a share require £192,500. In the year the company mined 1,801,198 tons of coal, 1,529,596 tons coming from the Wolvekrans section.

With the recent dividend notice shareholders of TWEEFONTEIN UNITED COLLIERIES were informed that the estimated profit for 1960 is £127,400, after providing £58,000 for taxation. It is intended to write £20,000 off property and mineral rights, while the interim and final dividends will absorb £108,437, the balance carried forward being estimated £36,430.

Elsewhere in this issue our Johannesburg correspondent makes reference to the fact that shareholders of the RAND SELECTION CORPORATION are to be asked to approve of arrangements with the BRITISH SOUTH AFRICA COMPANY, DE BEERS CONSOLIDATED, the ANGLO AMERICAN CORPORATION, RAND AMERICAN INVESTMENTS (PTY), and JOHANNESBURG CONSOLIDATED which will lead to a substantial enlargement of the Corporation. The value of its net assets is to be increased to over £100,000,000 based on present market prices and the scope of its activities widened. It is to be equipped to take a much more prominent part in the financing of mining and industrial development in Southern Africa. It is proposed to carry out these arrangements early in 1961, it is stated.

Orange Free State.—Last month PRESIDENT BRAND GOLD MINING gave the results of two deflections of Borehole SP 7 on the farm Stuirmanspan 405 referred to in the December issue. The Basal Reef in the first deflection was cut at 5,846 ft. and assayed 0·4 dwt. over 10·9 in., while in the second the intersection was at 5,851 ft., where it went 29·3 dwt. over 5·2 in.

Speaking at the annual meeting of the FREE STATE DEVELOPMENT AND INVESTMENT CORPORATION last month the chairman said that since the close of the financial year the company had acquired a participation in three more prospects being conducted by JOHANNESBURG CONSOLIDATED, one to the north of the new goldfield in the Leslie-Kinross area, one near the Klerksdorp goldfields, and one in the Kroonstad area.

Diamonds.—A notice issued by DE BEERS CONSOLIDATED MINES states that sales of diamonds effected through the central selling organization in the three months ended December 31 totalled £23,405,360, bringing the total for 1960 to £89,700,383. Of the total amounts £7,263,795 in the December quarter and £28,102,756 in the whole year represented industrial stones.

Tanganyika Territory.—At the recent annual meeting of TANGANYIKA DIAMOND AND GOLD DEVELOPMENT shareholders were informed that the new plant at ALAMASI, LTD., is now in operation. In the year to June 30 last 20,449 carats of diamonds were recovered from gravels yielding 6·454 carats per 100 loads.

Liberia.—It has been announced from Stockholm that the Export-Import Bank of Washington has authorized a $30,000,000 credit to Lamco—the LIBERIAN AMERICAN-SWEDISH MINERALS COMPANY—to finance the development of the iron-ore deposits in the Nimba Range. Swedish companies are to contribute about $50,000,000. The known deposits are estimated at more than 200,000,000 tons of ore with an average content of 65% Fe. Operations are scheduled to start in the first half of 1963 at the rate of 5,000,000 tons to 6,000,000 tons per annum, later to be increased to 10,000,000 tons. The Nimba project, including a 165-mile railway to the port of Buchanan, is owned by Lamco and the BETHLEHEM STEEL CORPORATION, Lamco holding three-quarters and Bethlehem one-quarter of the interests. In Lamco half of the shares are held by the Liberian Government and the other half by LIBERIAN IRON ORE, LTD. (LIO), of which the majority is owned by the Swedish Lamco syndicate and the balance by private interests in the United States and Liberia. In the Swedish syndicate three-sevenths are owned by the GRÄNGESBERG COMPANY, two-sevenths by ATLAS COPCO and NORDSTRÖMS LINBANOR, and two-sevenths by SKÄNSKA CEMENT, IFÖVERKEN, and SENTAB. Under a management agreement between Lamco and Bethlehem the Grängesberg Company is to handle the construction of the plant, the mining operations, and the transport of the ore to Buchanan. Bethlehem is to take about a quarter of the output, while most of the remaining quantities have been placed on long-term contracts.

Australia.—Last month the CONSOLIDATED ZINC CORPORATION and NEW BROKEN HILL CONSOLIDATED announced that agreement had been reached in principle whereby New Broken Hill will supply for an initial period of 12 years, commencing January 1, 1961, the major part of the lead and zinc concentrate requirements of the new smelting plant being erected at Cockle Creek, N.S.W., by the SULPHIDE CORPORATION, at present a wholly-owned subsidiary of Consolidated Zinc. New Broken Hill is to acquire a 25% interest in the ordinary share capital of Sulphide. The smelter will operate the Imperial Smelting process developed at Avonmouth and it is due to come into operation in the second half of 1961. A similar plant was completed at Swansea early in 1960 and has achieved a very satisfactory level of operation.

Earlier this month the RIO TINTO MINING CO. OF AUSTRALIA PTY. announced that it is shortly to be converted into a public company and file a prospectus for an issue of 1,000,000 ordinary 5s. shares at 7s. a share. Rio Tinto Australia owns 51% of the issued ordinary capital and the whole of the preference capital of MARY KATHLEEN URANIUM, its other major investment being a 75% investment in FITZPATRICK INDUSTRIES PTY., which through two wholly-owned subsidiaries is engaged in blue metal quarrying, sand winning, and road contracting in the Sydney area. Rio Tinto Australia also maintains a substantial mineral exploration programme and at present areas in north-west Queensland and western Tasmania are being examined.

At the recent annual meeting of GOLD FIELDS AUSTRALIAN DEVELOPMENT shareholders were told that ore at the Mount Ida mine is now only enough to last a few months. Diamond-drill holes put down below the bottom level have so far given no helpful indications, although a limited amount of the planned drilling remains to be completed. The work proceeding at the south end of the mine, principally on the 6th Level, is not without encouragement, it is thought, yet too early " to establish the significance of the results obtained, particularly as in the area in question there is much faulting." A small tonnage of ore is being stoped from this area.

Malaya.—A circular to shareholders of HONGKONG TIN issued earlier this month refers to a recent suggestion that consideration should again be given to the possible development of an opencast mine in the northern portion of the property, where the previous operations of the dredge and the subsequent grab dredger experimental workings have indicated the occurrence of a local enrichment below the maximum digging depth of the dredge. The nature of the ground and bedrock in this area is such, however, that the potentialities of this deep deposit could be ascertained only by exploratory operations. The recommendations have been considered, but a decision to incur the substantial initial expenditure must, it is stated, " await clearer indications regarding developments in the near future."

At an extraordinary meeting of BERJUNTAI TIN DREDGING held in Kuala Lumpur earlier this month it was to be proposed that the capital be increased to £2,000,000 by the creation of 4,000,000 new ordinary 2s. shares. It was proposed to capitalize £706,625 standing at Share Premium Account.

Colombia.—In the three months to September 30 last PATO CONSOLIDATED GOLD DREDGING treated 6,190,000 cu. yd. of ground and recovered 24,548 oz. of gold. The profit for the nine months to September 30 is estimated as $375,000.

Canada.—On January 6 shareholders of RIO ALGOM MINES were informed that the company had commenced production of copper concentrates in its Pronto mill and plant, near Spragge, Ontario. The Pronto mill discontinued uranium production in the spring of 1960 and has been converted to handle copper ore trucked to it from Rio Algom's Pater property, situated on the north shore of Lake Huron. This mine was acquired through purchase by PRONTO URANIUM prior to its amalgamation with three other Rio Tinto uranium mining companies into Rio Algom Mines. Since Rio Algom took over the property a total of more than 10,000 ft. of development work has been recorded and the shaft has been deepened to 1,126 ft. and an underground hoist room and stope rise completed. A start on further shaft sinking is now being planned to a new bottom level at 2,100 ft. Present ore reserves are calculated at approximately 1,000,000 tons, grading about 2% copper to the 950-ft. horizon.

Sweden.—It was recently announced that JOHNSON, MATTHEY AND CO. had acquired a controlling interest in the Swedish precious metal company A/B GÖSTA NYSTRÖM, of Stockholm. This company supplies precious metal products for all industrial purposes. The company is, in future, to be known as A/B NYSTRÖM AND MATTHEY.

United Kingdom.—Shareholders of LAPORTE INDUSTRIES, LTD., have been informed that the company has purchased from HEAD WRIGHTSON AND CO. the whole of the issued capital of the CUPOLA MINING AND MILLING COMPANY for an undisclosed price. Cupola is engaged, principally, in the treatment of fluorspar and barytes and Laporte intends to meet the rising demand for acid-grade fluorspar by expanding production at the flotation plant at Stoney Middleton, Derbyshire.

Consolidated Zinc Corporation.—At an extraordinary meeting of the Consolidated Zinc Corporation held in London on December 29 shareholders ratified the agreement with the BRITISH SOUTH AFRICA CO. HOLDINGS, LTD., providing for the issue of £10,000,000 5½% unsecured loan stock 1966–71 and the granting of options to subscribe for up to a total of 2,285,714 ordinary shares of £1 each in the capital of the company at 87s. 6d. per share. Shareholders also approved an increase from £20,000,000 to £25,000,000 in the authorized capital of the company. It was announced that the consent of H.M. Treasury had been obtained to the transfer to a company to be jointly owned by CONSOLIDATED ZINC PTY., and the KAISER ALUMINUM AND CHEMICAL CORPORATION of the whole of the issued share capital of COMMONWEALTH ALUMINIUM CORPORATION PTY.

DIVIDENDS DECLARED

* Interim. † Final.
(Less Tax unless otherwise stated.)

African and European Investment Co.—Pref. 3%, payable Feb. 16.
†**Amalgamated Collieries of South Africa.**—3s., payable Feb. 16.
Anglo American Corporation of South Africa.—Pref. 3%, payable Feb. 16.
Anglo American Investment Trust.—3%, payable Feb. 16.
***Anglo-Transvaal Collieries.**—7½d., payable Feb. 14.
***Angola Diamond.**—Esc. 20.
†**Apex Mines.**—3s., payable Feb. 16.
†**Associated Manganese Mines of South Africa.**—Ord. 2s. 6d., payable Feb. 14.
***Ayer Hitam Tin Dredging.**—7½d., payable Jan. 25.
†**Burma Corporation (1951).**—3%, free of Burma tax.
†**Consolidated Diamond Mines of South-West Africa.**—Pref. 4½d., Ord. 15s., payable Feb. 15.
†**Corner House Investment Co.**—7·2d.
†**Coronation Collieries.**—7½d., payable Feb. 16.
De Beers Consolidated Mines.—Pref. 10s., payable Jan. 28.
***Halkyn District United Mines.**—1s., payable Jan. 17.
***Kepong Dredging Co.**—1s., payable Jan. 27.
***Malayan Tin Dredging.**—9d., payable Dec. 30.
***Natal Coal Exploration Co.**—4d., payable Feb. 16.
***Nchanga Consolidated Copper Mines.**—2s. 4·8d., payable Feb. 2.
†**New Guinea Goldfields.**—3d.
***Phœnix Colliery.**—10½d., payable Feb. 16.
***Pusing Rubber and Tin.**—1s. 11½d., free of tax, payable Jan. 21.
†**Rand Mines.**—3s., payable Feb. 16.
***Rhodesia Broken Hill Development Co.**—4·8d., payable Feb. 2.
***Rooiberg Minerals Development Co.**—1s. 6d., payable Feb. 16.
†**Siberian Syndicate.**—2s., payable Feb. 1.
***South African Coal Estates.**—1s. 6d., payable Feb. 16.
***Southern Malayan Tin Dredging.**—1s. 3d., payable Dec. 30.
†**Springbok Colliery.**—1s., payable Feb. 16.
†**Transvaal Consolidated Land and Exploration Co.**—2s. 3·6d., payable Feb. 16.
†**Transvaal Gold Mining Estates.**—3·6d., payable Feb. 16.
†**Tweefontein United Collieries.**—10½d., payable Feb. 14.
***Union Minière du Haut-Katanga.**—600 Belgian Fr.
***Vierfontein Colliery.**—4d., payable Feb. 16.
†**Vryheid Coronation.**—6d., payable Feb. 16.
†**Weardale Lead Co.**—12½%.
***Welgedacht Exploration Co.**—4·8d., payable Feb. 16.
†**West Rand Consolidated Mines.**—Def. 127s. 6d., payable Mar. 3.
***West Witwatersrand Areas.**—2s.
***Western Mining Corporation.**—6d. Aust, payable Feb. 17.
†**Zaaiplaats Tin Mining Co.**—1s. 4½d., payable Mar. 3.

METAL PRICES

Jan. 10.

Aluminium, Antimony, and Nickel per long ton; Chromium per lb.; Platinum per standard oz.; Gold and Silver per fine oz.; Wolfram per unit.

	£	s.	d.
Aluminium (Home)	186	0	0
Antimony (Eng. 99%)	210	0	0
Chromium (98%–99%)		7	2
Nickel (Home)	600	0	0
Platinum (Refined)	30	5	0
Silver		6	7⅜
Gold	12	14	5
Wolfram (U.K.)			
(World)	7	7	6

Tin, Copper, Lead, Zinc } See Table, p. 48.

Tonsteins: A Possible Additional Aid to Coalfield Correlation

A description of Continental occurrences and their mode of formation

Iain A. Williamson, B.Sc.[1]

Abstract

A review is given of foreign literature describing tonsteins. These are thin bands of kaolinitic rock, generally found intercalated in coal seams and of considerable importance in Coal Measure correlation. The major theories concerning their mode of formation are described.

Introduction

In recent years there have been a considerable number of continental publications describing the occurrence, probable modes of origin, and utilization of " tonsteins." Tonsteins are essentially argillaceous rocks containing kaolinite in a variety of forms together with occasional detrital and carbonaceous material. Their distribution is widespread in Continental Carboniferous rocks of Westphalian age and since each bed possesses specific characters they are important aids to correlation.

So far no tonstein horizon has been recorded in Britain. However, since they are widespread on the Continent it seems probable that their apparent absence in our coalfields is due merely to a lack of knowledge on the part of many British geologists. It seems most unlikely that they should be absent and accordingly this review is given in the hope that interest will be stimulated amongst British Upper Carboniferous workers with the result that another aid to correlation will be forthcoming.

Characteristics

(*a*) *Occurrence*

Tonsteins generally occur as thin beds in strata of Coal Measure facies. The Continental examples so far described are of Carboniferous age, but in North America a late Cretaceous or early Tertiary example has been recorded (Rogers, 1914).[2] Their thickness varies between 140 cm. to 1 mm. but mostly averages a few centimetres. Individual beds may also vary considerably in thickness and locally may be absent. They commonly form dirt-bands in coal seams although they may also be found in the adjacent roof strata. Instances have been noted where a tonstein passes laterally into shale (Scheere, 1956, p. 28), siderite (*op. cit.*), and sandstone (Herbst, 1955, p. 88), although such occurrences are infrequent. When associated with a coal seam the latter is generally durain or, more rarely, a cannel coal.

Many of the beds have a large lateral extension and may be correlated over considerable distances—for example, between the Pas de Calais and Nord coalfields of France, the Sambre-Meuse and Kempen coalfields of Belgium, the Dutch Limburg and Peel coalfields, and the Ruhr coalfield of West Germany—a distance of some 200 miles. Previously such absolute correlation in Westphalian strata has been limited to marine horizons. About 10 tonsteins have so far been proved to be common to all or most of the coalfields previously mentioned although certain others have a more limited distribution (Scheere, 1958, Fig. 3).

(*b*) *Macroscopic Characters*

In hand specimens tonsteins are compact rarely-laminated rocks bearing superficial resemblance to mudstones or siltstones. Well-developed jointing is noticeable vertical to the bed and in other directions the fracture is uneven or semi-conchoidal. In colour a tonstein may vary between black, grey, and white and the individual bed may also be similarly variable between different localities. Generally the darker tonsteins occur as intercalations in the coal seams. A speckled appearance may sometimes be noted on a freshly broken surface of a tonstein, resulting from the distribution of light-coloured kaolinite masses (see later). The streak is often white (Scheere, 1958, p. 305) and is always of a lighter colour than that of the rock itself. However, for the certain identification of a

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[2] A list of references is given at the end of this article.

Fig. 1.—Tonstein, Hasard Collieries, Belgium : Section parallel to Seventh Poignées Seam, × 120.

tonstein, apart from specimens in which the kaolinite vermicules (see later) can be seen with the unaided eye, a microscopic examination is generally essential.

(*c*) *Microscopic Characters*

The most noticeable feature under the microscope is the general predominance of kaolinite both in the groundmass and in larger district units. Detrital accessary minerals also occur though often in very small amounts. The kaolinite occurs in three ways, as :—

(i) Vermicules or lamellar crystals ;
(ii) crypto or micro-crystalline aggregates forming " spherules " or " balls," or as
(iii) cryptocrystalline groundmass.

The vermicules are the most striking feature of these rocks (Fig. 1). They are of characteristic habit, having generally a yellowish or brownish colour under ordinary transmitted light. Their dimensions are variable, attaining a maximum length of about 2 mm. Both vermicules and crystals are sometimes aligned roughly parallel to the bedding. Cleavage, almost always developed, is perpendicular to the long axis of the vermicule (Fig. 2). Smaller vermicules can often also be observed in the micro-crystalline aggregates.

In Belgium it has been shown that the vermicules have in many instances thin layers of another mineral of greater birefringence between the cleavage (Scheere, 1956, p. 19) which is considered to be illite (Scheere, 1958, p. 308). Elsewhere (Schuller and Grassmann, 1950) vermicules have been described which are entirely composed of illite or of kaolinite. Certain authors consider the vermicules to be composed of " leverrierite," a mineral first described by Termier (1889). Since then considerable confusion has arisen regarding the use of the term (Scheere, 1958, pp. 306–310) and it appears advisable to abandon the name " leverrierite " which has more recently been identified with kaolinite (Grim, 1953, p. 39).

In summary, the types of vermicule which may occur are composed of kaolinite or of illite exclusively or consist of a mixed-layer mineral composed of illite and kaolinite. The kaolinite crystals are generally rod-like but otherwise have similar properties to the vermicules. They are more common than the vermicules and generally are of smaller dimensions.

Apart from the groundmass kaolinite also occurs in crypto- or microcrystalline aggregates with a tendency to form roundish " balls " or " spherules." Their dimensions vary between several tenths of a millimetre to about 5 cm. (Schuller, 1951, p. 108). Depending upon the occurrence of crystals

or spherules in a tonstein Schuller (*op. cit.*) employs the terms "Krystall Tonstein" (Fig. 1) and "Graupen Tonstein," Figs. 4 and 5, respectively.

The groundmass consists largely of cryptocrystalline kaolinite together with a small percentage of vegetable matter and accessary minerals, the latter consisting chiefly of detrital quartz and mica, with rarer other minerals of which tourmaline, zircon, apatite, calcite, dolomite, and siderite have been recorded.

Mode of Formation

Of the various theories advocated for the formation of tonsteins three are maintained by present-day workers. The theories may be termed sedimentary, volcanic, and diagenetic. During recent years the bulk of published material supports the last.

(i) *Sedimentary Origin of Tonsteins*

The theory of sedimentary origin was first proposed by Pruvost (1934) in a description of tonsteins in the Sarre coalfield. It was considered that these were formed from kaolinite-rich sediments derived originally by the erosion of neighbouring granite massifs. Resulting from this erosion the fine kaolinite particles were transported to and deposited in the coal swamps. Subsequent recrystallization of the kaolinite then took place which resulted in the crystals and masses of that mineral in the tonsteins. Supporting this theory Chalard (1952, p. 76), describing tonsteins in Northern France, quotes the presence of granite and gneiss pebbles in certain coals as additional evidence for the contemporaneous erosion of granite outcrops and therefore a probable source of the kaolinite.

(ii) *Volcanic Origin of Tonsteins*

Principally defended by Stach (1950), the volcanic theory concerns the formation of tonsteins resulting from the deposition of showers of kaolinite or kaolinized volcanic ash. The principal argument in support of a volcanic origin is the satisfactory explanation by this theory of the very considerable lateral extension of most tonsteins. Additional evidence quoted in support of the theory is the occurrence of angular quartz fragments and occasional crystals of zircon.

However, such a theory was anticipated by Termier (1923, p. 49), who remarked that a volcanic origin must be supported by the occurrence in the associated sediments of other volcanic products and apart from one instance in North America (Rogers, 1914, p. 303) these seem to be notably absent.

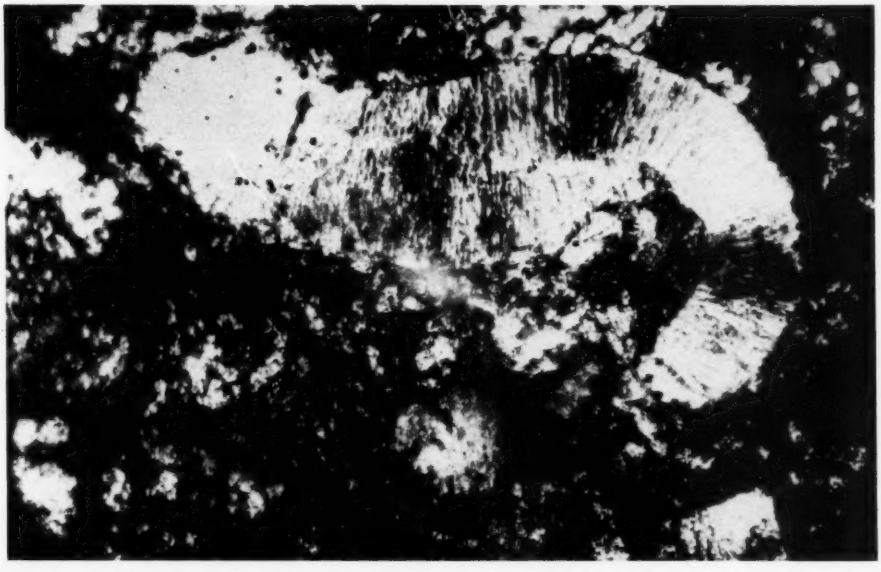

Fig. 2.—Zwartberg Collieries, Belgium : Section of Tonstein underlying Aegir marine band, × 120.

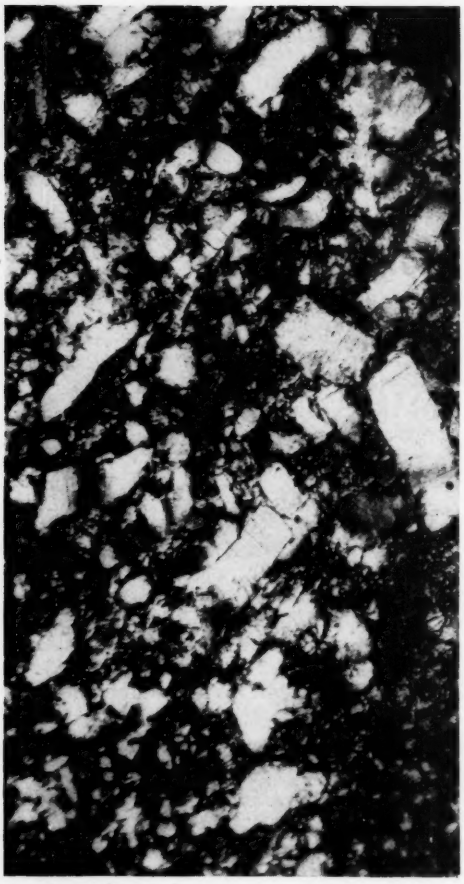

Fig. 3.—Tonstein Maxence, Valenciennes, France : Section parallel to bed, polarized light, × 60.

Similarly M. and R. Teichmüller and co-workers (1952), noting the mutual interference of the kaolinite crystals, support their formation *in situ*. Again (*op. cit.*) the close association of tonsteins with durain or cannel coal indicates a sub-aquatic environment of formation and this could account for their widespread distribution irrespective of a possible volcanic origin. The theory is also strongly opposed by Scheere (1955, p. 32) who remarks that the detrital quartz content of both tonsteins and ordinary Coal Measure shales are identical and the latter are most certainly not volcanic in origin.

(iii) *Diagenetic Origin of Tonsteins*

Most recent work in the study of tonsteins favours the diagenetic theory of origin. Considerable work has been done in this respect and for more complete accounts the reader is referred to the work of Kulbicki and Vetter (1955), Millot (1949), and Scheere (1955, 1958). Essentially it is considered that the kaolinite was formed by recrystallization *in situ*, being derived originally from an illite-rich clay in a markedly acid environment.

Other than in the clay mineral content the normal Coal Measure shales and the tonsteins have a closely similar mineralogical content. The predominant clay mineral of the shales is illite and, as previously described, that of the tonsteins is kaolinite. It is therefore argued that the origin of the tonsteins concerns the transformation of illite to kaolinite. Millot (1949, p. 291) considers that the latter is formed *in situ* and results from the " degradation " of illite due to ion exchange in an acid environment. A suitable environment is found in the Coal Measure swamps due to the humic and sulphuric acids present there. Under such conditions and providing that they remain stable for some time, all the illite will become transformed into kaolinite. The change is considered to take place prior to the deposition of the overlying strata, since, if otherwise, these sediments would also be predominantly kaolinitic and this is not the case. The principal factors in support of this theory are :—

(*a*) Tonsteins are closely associated with coal seams. This association favours an acid environment at the time of deposition.

(*b*) The coal below a tonstein is durain or cannel, both indicative of a sub-aquatic environment. This is also supported by the considerable lateral extension of the beds.

(*c*) The mutual interference of kaolinite crystals indicate an *in situ* origin. (A slight transport of the kaolinite may be envisaged in rare tonsteins having some stratification (Scheere, 1958, p. 303) or grading (Dollé, 1954, pp. 41 and 44).)

(*d*) The delicate nature of the kaolinite crystals and vermicules preclude their transportation over any considerable distance.

(*e*) The transformation of illite to kaolinite is indicated by the occurrence of residual illite in the vermicules.

(*f*) The occurrence of similar accessary minerals in both tonsteins and associated shales favours a common primary source.

Fig. 4.—Tonstein Hermance, Thiers, France : Section parallel to bed, polarized light, × 60.

Tonsteins and Correlation

Since most tonsteins possess characters by which the individual bed may be identified and also have considerable areal extent their use in correlation is of importance. Moreover, since many occur as intercalations in coal seams they can be readily located in the mine workings without a time-consuming search of the adjacent strata.

Methods of correlation employing the use of tonsteins generally consist of both macroscopic and microscopic examination of the bed (Scheere, 1956, p. 48 ; Bouroz *et al.*, 1953, p. 137). The chief macroscopic characters utilized are thickness, colour, and geometric relations of a bed. In regard to the latter, a " unit " made by two or more relatively close tonsteins may be most noticeable and the beds sometimes correlated without recourse to the more tedious microscopic methods. The usual microscopic examination of a tonstein involves the studies of a section through the whole bed and a series of sections parallel to the bed.

A good example of the stratigraphic utilization of tonsteins is that of Bouroz *et al.* (1953) for the coalfields of Northern France. Here a most commendable terminology is used in which the tonsteins of any one Westphalian division are named in alphabetical order from the base upwards. The actual division in which the bed occurs is indicated by the last

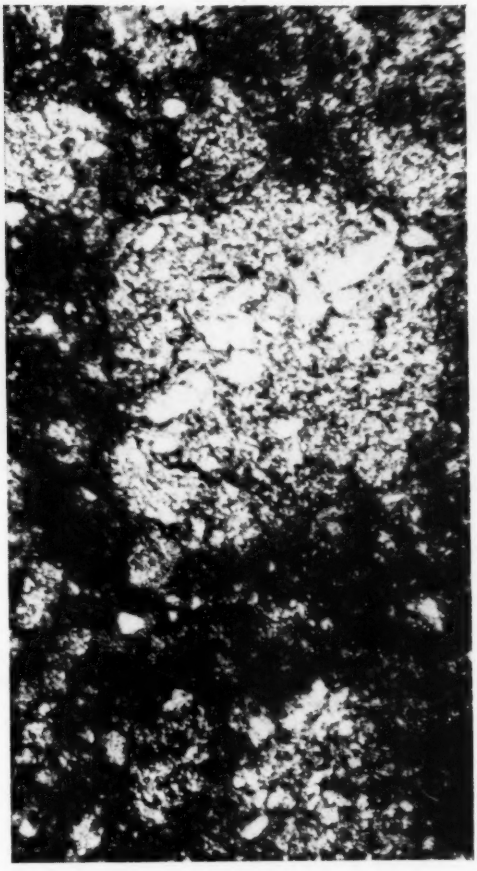

Fig. 5.—Tonstein Hermance : Section, polarized light, × 60.

or last but one letter in the name. Thus the tonsteins Elbe, Fraidherbe, and Viterbe all occur in Westphalian B and the lowest horizon is the Elbe. Again the tonsteins Talence, Ulric, and Valence all occur in Westphalian C and the uppermost bed is the Valence.

Acknowledgments

The author wishes to thank Doctors W. P. Van Leckwijck and J. Chalard for their considerable help in providing specimens of the continental tonsteins.

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Removing Overburden at a Mine in Arizona

A note on progress at the Asarco Mission Mine in the Arizona desert

J. Grindrod

Substantial progress is reported in the development of the large new Mission open-cast copper-mining project of the American Smelting and Refining Company in the Arizona desert, located 15 miles south-west of Tucson. Trouble is, however, being experienced in removing the overburden, which consists of a bed of sand no less than 250 ft. thick over the ore-body. This covering is having to be removed not only for the pit itself but also to make possible the construction of foundations for the mill and the main difficulty is in preventing the soft material from caving in.

In order to extract some 45,000 tons of metal annually from this body American Smelting and Refining will have to mine 15,000 tons of ore a day. Production at this rate is due in 1962 and the project is being financed with the proceeds received from the sale of the Garfield, Utah, smelter and of the company's holding of common stock of the

Mission Mine, Arizona.

Cerro de Pasco Corporation. The project includes a portion of the San Xavier Indian Reservation, which is held under permit and lease from the Papago Indian owners.

Exploratory work at the Mission Project has been carried out since 1954 by the company and during the past five years some 346 diamond-drill holes have been put down with a total length of more than 190,000 ft. To check the drilling results and to obtain bulk samples for pilot-mill tests a shaft was sunk and drives, cross-cuts, and raises totalling more than 2,200 ft. were driven in the ore zone. This was completed in the first half of 1959 and confirmed that the drill-hole interpretations were correct. Large samples taken from the underground workings were run in a test mill at the University of Arizona to establish the economic recovery of copper, where engineering cost estimates of bringing the property into production at a rate of 15,000 tons of ore per day were also completed during the period.

On July 28, 1959, the directors authorized the expenditure of $43,500,000 to bring the property into production. Soon after contracts for the auxiliary facilities were entered into detailed mill design started and the stripping of overburden begun. By the end of the year the general office building had been completed and occupied and in January, 1960, the contract for the construction of the mill was let.

When completed for production the new Mission mine will cover approximately 250 acres. Output will be twice that of the company's Silver Bell operation—in the same general region but north-west of Tucson. Concentrates are to be sent from the mill at the mine site for smelting into blister copper at the nearby Hayden plant and possibly at the El Paso, Texas, plant. Refining is to be done at the company's Baltimore and Perth Amboy refineries. The output of the Mission Mine is expected to add about 5·6% to the U.S. domestic production of copper.

International Strata Control Conference, 1960

A summary of proceedings at the May gathering in Paris

Introduction

The subject of strata control has attracted the attention of mining engineers for centuries but it is only in the last 20 years that an all-round attempt has been made to approach this problem scientifically. The importance of the subject is quite clear from the fact that during the past decade there have been four international strata control conferences—in Belgium (Liege), 1951, West Germany (Essen), 1956, East Germany (Leipzig), 1958, and the most recent one in France (Paris), May, 1960.

The 38 papers given at the Paris conference were restricted to a limited number of problems and these were divided into the following groups: A—Supports (5); B—Studies on Small-Scale Models (5); C—Rock Characteristics (5); D—Underground Measuring Methods and Equipment (6); E—Observations and Measurements in Roadways (6); F—Observations and Measurements in Faces (5); G—Influence of the Method of Working on the Behaviour of the Strata in Rock Bursts (6). The figures in brackets indicate the number of papers in each group. Besides these 38 papers emanating from different countries on different problems of strata control national reports were also sent from Austria, Belgium, United Kingdom, Bulgaria, France, East Germany, West Germany, Holland, Hungary, Japan, Poland, U.S.A., and the U.S.S.R.

In what follows it is intended to describe the salient points from technical papers, a brief review of the national reports being given at the end.

A—Supports

The first paper in this group, by L. Dubois, of Belgium, was entitled " Twenty-five Years Experience with Metal Face Supports at Winterslag." In thin seams (below 80 cm.) it was observed that when roof control was good the seams became " hardened " to such an extent as to hinder the advance of a coal plough. On the other hand when there was bad roof control ploughing became impossible and it was very difficult to set cantilever bars over the armoured conveyor. As a result it was considered that a prop with a constant yield load and fitted with small bars was suitable for ploughing in thin seams. The author states that measurements of the resistance of the floor to penetration are carried out systematically in the face before setting the final supports. Strength values obtained for the floor rock ranged from 50 to 300 kg./sq. cm. Floor with a strength below 200 kg./sq. cm. was considered soft because it required the use of enlarged sole-plates. The strength values obtained for the roof were found to be generally higher than those for the floors and ranged between 200 and 400 kg./sq. cm. On the coal face the convergence was not continuous but took place in jerks, jerks not simply related to the various stages of work at the face but dispersed in time and in space under the effect of the irregular distribution of varying points between roof on the one hand and the coal or stowing material on the other. Mention is also made of the organization responsible for repairing the props at a colliery. The author states that 2 m. long props are about 11 times more likely to buckle than the 0·6 m. props.

The following expression was given from which the cost price of strata control on a coal face could be calculated :—

$$P = P_1\delta + P_2S$$

where

P is the cost of strata control in B.fr./sq.m.
P_1 is the cost per prop in B.fr. per day
δ is the number of props set per sq. m. of exposed roof
P_2 is the number of workmen necessary per sq. m. for setting and removing props in the face, excluding strip packing.
S is the average wage with welfare charges for these workmen.

The term

P_1 is obtained by adding the following three figures on a yearly basis :
a_1—technological depreciation and interest on the capital invested.
a_2—losses.
a_3—maintenance and scrap.

A table showing the values for these different components as recorded for three particular cases was given. It is pointed out that the economy of a face improved as its rate of advance rose—*i.e.*, as the coefficient of utilization of the equipment increased. The author mentioned that the hydraulic prop, with its reliable and high load yield and the regularity of load yield curve, was best suited for faces where there was difficult roof condition. On the other hand the Wiemann friction prop, which was less expensive and had a higher buckling load and extensibility, was to be preferred on faces which did not present any particular difficulty and also on those faces where rock burst was occasioned by the control of the main roof.

The second paper in this group was delivered by Oberbergrat A.D. Otto Kuhn, of West Germany, and covered " Investigations into the Adaptability of Hydraulic Frame Supports to Brittle Roof Conditions." The author mentioned that a new type of hydraulic frame support was being tried in the Ruhr and it was designed so that the frames advanced longer than the distance between the front and rear props of the frame. In this particular case the breaking up of the immediate roof strata by the action of the support frames was relatively unimportant. On the basis of photo-elastic investigation bars fitted with layers of rubber in contact with the roof were tried along with hydraulic props. It was found that the rubber-covered plate bars caused less damage to the roof strata, even completely-disintegrated rock strata being prevented from breaking out. In another trial the weight of the roof rock falling down was noted and it was found that the bars with rubber covering gave on an average 0·12 kg. of broken roof rock compared to 0·34 kg. for those without a rubber covering.

The author concludes that the bar elements lying on the hydraulic props should be plate shaped. This will ensure a low specific pressure where the surface is irregular. When the bar is covered with rubber its surface adjusts itself more readily to the irregularities of the roof and maintains low shear stress in the rock. It also eliminates any " cutting " action where there are " steps " in the roof rock. The author recommends that the connexion between the plate-shaped bars should be such that it lies in " springy " contact with the roof to prevent the falling out of pieces of rock between the plate bars. On the basis of these trials there was designed a support which consisted of a hydraulic support frame and each prop in the support unit was fitted with a rubber-covered, eliptical-shaped plate. The connexion between the two props consisted of a broad steel strip on which was placed a rubber block which was covered by a thinner steel strip. This thin steel strip was also covered by rubber. The trials with this support unit are proceeding.

The third paper, entitled " Hydraulic Power-Operated Supports in Service at the Bruay Group of the Houilleres Nationales du Nord Du Pas-de-Calais," was given by R. Adam and C. Chassagne, who dealt with the development of Sahe Somemi self-advancing hydraulic support. The authors have condemned the principle of advancing powered supports in tandem. On the basis of time study they have shown that a saving of 60,000,000 francs per annum would result as a result of the use of these self-advancing supports on a 140 m. long coal face. Besides dealing with the development of self-advancing supports the authors have described the application of a coal plough and also a 135-h.p. cutter loader. Daily advance of 3 m. to 4 m. and a district O.M.S. of 20 tons was achieved by using powered support system.

A. D. McLuckie of the U.K. then reviewed " Frame Type Powered Supports." The author dealt with two types of self-advancing supports—*viz.*, the Dowty Roof Master and the Dobson Double-Two self-advancing support. Among the conventional support system he dealt briefly with three types :—(1) Link Bars and props, (2) Slide Bars and props, (3) Stagger Bars and props.

One of the commonest features of these conventional types is that when a prop has been set to the roof the support is never removed from the roof which it supports until such time as the roof no longer requires support and is allowed to cave. The application of slide bar and props seemed to the author to be most virtuous from the aspect of roof support and least roof disturbance. He remarked that with powered supports the application of support under pressure and its subsequent release causing flexure of the roof could in many circumstances lead to an adverse effect upon the roof as well as roof control problems if the roof was fractured and required continuous support. With the Dobson Two self-advancing support it is possible to achieve setting loads equivalent to the yield loads of the support. The

author pointed out that when using high setting loads the load builds up over a short period of time and this is in effect equivalent to applying impact loads. This may induce rupturing of the strata at much lower values than the normal and may cause deterioration of conditions in certain circumstances.

For the purposes of analysing the effectiveness of the support and its distribution the author classified the support in two types—*viz.*, (1) main support behind the conveyor and (2) cantilever support above and in front of the conveyor. To prevent the rocks from the caved goaf over-riding the props plates may be slung at the back of the roof beams at the waste edge. The author mentioned future developments in regard to the props on the face side of the conveyor and operated by the power available for operating the main supports and remotely controlled. This is to prevent injuries to the men working behind power loaders. The development of a hydraulically-operated sprag, which is attached to the roof bar to prevent the coal falling down from the face was also mentioned. The author emphasized that the selection of the different types of powered supports to varying condition is dependent more on the economic considerations than the strata control factors.

A. Wright, also from the U.K., then discussed " Practical Applications of Chock-Type Power-Operated Support Systems." Since the introduction of the first powered supports in 1951 there were (up to September, 1959) in British coal mines 37 faces solely supported and 28 faces mainly supported by powered supports. In addition there are a number of faces in which powered supports are used only at the waste edge and on some parts of faces with trial installations. There are four types of powered supports which have been developed beyond the prototype stage. Out of these one uses oil as the hydraulic medium and the others use water with 2% of soluble oil added. The author dealt with two types of powered supports—*viz.*, Gullick chocks and Desford powered supports (goal-post type and the Gullwing type). The application of these supports on the Anderton shearer, A. B. trepanner, Huwood slicer, and Plough face was described. Also described was the Gullick GRS5 system which overcomes both the problem of maintaining adequate support when chocks are being advanced and reducing the distance from supports to the coal face. This system is, in fact, a combination of both frame and chock type of powered support. The powered supports work to best advantage where the waste is totally caved, though strip packing is done on some faces. It has been mentioned that the use of powered supports may reduce the roof/floor convergence by as much as 50%.

It was suggested that the close spacing of powered supports might be necessary and that single rows were best. To install powered supports on a face which must continue to advance it was mentioned that 10 units should be installed each day on a shift when there is least work at the face. The author pointed out that investigations were proceeding to determine the influence of different setting and yield loads which included measurement of stress in the coal, convergence, chock loading, roof curvature, lateral roof stresses, and waste resistance.

B—Studies on Small-Scale Models

The first paper in this group entitled " Model Tests Illustrating the Effects of Different Roadway Supports " was given by O. Jacobi and G. Everling, of West Germany. The behaviour of different types of roadway supports were investigated by using models which were made on a scale of 1 : 10. Concrete models aggregated from either Portland cement or argillaceous fusion cement or quartz meal were made to represent, according to mix, coal, clay shale, and sandstone respectively, the operative strength scale being as 1 in 10. Different models were made to represent a trapezoidal section unsupported roadway, an arched unsupported roadway, an arched roadway supported with GI120 rigid arches, hinged arches supported on chocks, yielding arch supports and frame supports (timber props and type GI120 metal bars). The models were subjected to different modes of loading. These experiments throw considerable light on the significance of horizontal rock stress which had hitherto only been treated in rather a casual fashion. It was not possible with any of the six models tested to arrive at a support which would stand up to all types of loading under consideration. However the yielding form of support was found to resist the deformation of the roadway cross-section more effectively. The trapezoidal section roadway underwent considerably more deformation than did the arch under similar loading conditions. The authors used strain gauges of the strip type

encased in araldite prisms to measure the pressure at different points in the model.

A. Il'sbtein, of the U.S.S.R., then reviewed "The Influence of the Resistance of the Support System on the Manifestation of Rock Pressure in Long-Wall Faces." Although his paper was mainly concerned with the model study the author stated that on long-wall faces in the Donetz basin an increase in the prop density of 60% to 80% had no marked influence on the loading of individual props.

To study the rock pressure phenomena models on a scale of 1 : 10 to 1 : 40 of long-wall faces were tried in the Mining Institute of the Academy of Sciences of the Soviet Union. "Mixtures of plaster binder" were used to represent the Coal Measure strata. The model study showed that there was an optimum value of the rigidity (density) of the props used on a long-wall face above which there was little change in the displacement of the strata if the prop rigidity was increased. At some value below the optimum value the roof displacement would increase appreciably through separation of the lower roof beds and this was likely to be accompanied by fissuring of the strata. It was remarked that there was a minimum movement of the strata which could not be reduced at working depths exceeding 150 m. to 200 m. even by the introduction of powerful supports. The author expressed in a tabulated form the calculated values of the displacement for varying depths—*e.g.*, 50 m., 100 m., 200 m., and 400 m.—at a distance of 4 m. from the coal face for different values of the support resistance. Thus by using support resistance of 20 t./m.^{2} the roof movement at depths of 50 m. and 400 m. would be 42 mm. and 121 mm. respectively. The model experiment showed that the use of hydraulic props or constant resistance props in comparison with props giving rising resistance had a positive action in preventing bed separation and it improved the conditions on the face. On faces with soft roof and floor strata increasing the support density usually leads to the improvement in the support conditions in the face area, but the author stated that in these particular conditions also the use of rationally designed coverings and supports could give satisfactory results even with normal prop density of 1 to 1·4 prop/m.^{2}. Doubt was expressed as to the general belief regarding the efficiency of very rigid support systems. It was stated that on long-wall faces using total caving only the lower layers of the strata with a thickness of 1·5 to 3 times that of the seam thickness caved in. It was recommended that special metal supports (breaker props, chocks, etc.) should be used on faces using timber or mixed supports, but where metal supports were used the special supports should be used only where the roof strata caved with difficulty, where there were extremely weak surrounding strata, or where there was considerable displacement of roof likely to exceed the yield values of the metal props.

Theoretical work for model experiments, correlating subsidence, and strata control, was described by three Polish authors, J. Bodziony, J. Litwiniszyn, and A. Smolarski in a paper entitled "New Research into Rock Masses Treated as Media Characterized by Stochastic Equations." The equations which were derived are applicable to stochastic medium—*e.g.*, dry sand. Principles of linearity and superposition were used to derive the equations. For model experiments a chamber measuring 55 cm. by 40 cm. by 4 cm. (internal dimensions) was made and was filled with sand. The larger dimensions of the chamber lay in the vertical plane. The sand was allowed to flow through different slits made at the bottom of the chamber. The density (defined as the ratio of the true particle volume to the volume occupied by the mass) of the sand was varied by using jets of different diameter which were used to pass the sand in the chamber. The subsidence trough formed by using the high density sand was deep and narrow but when lower density sand was used the trough became shallower and wider. Vertical and horizontal displacements of markers set on a fixed level were also measured. The experimental subsidence trough corresponded to the theoretical ones. The model study showed that the principles of linearity and superposition were valid within narrow limits of the experiment and the principles were no longer valid beyond this limit.

The fourth paper, "Stowage Pressure in Steep Measures," was given by two German authors, H. Jahns and G. Brauner, who derived an equation for calculating the pressure exerted by stowing materials on the side walls, roof, floor, and on the end surfaces of a model. In the model experiment they used fine gravel (grain size 3 mm. to 5 mm.), dry and wet sand, broken blast-furnace slag, and washery dirt. The equations, which were derived, are only valid for the period im-

mediately following the insertion of the stowage and cannot be applied once face convergence exerts a supplementary clamping effect on the stowage. The model test showed that the loading of the stowage cavity wall decreases further if the wall yields. The authors concluded that in an underground cavity the stowage is under the influence of " silo-effect." This phenomena arises from wall friction and its effect is that, with increasing filling height, the pressure in a given layer of stowage material does not increase linearly with the filling height but tends rather towards an upper limiting value.

V. F. Trumbachev of the U.S.S.R. then described some investigations by using photo-elastic models in a paper entitled " Experimental Investigations into the Distribution of Stresses in Inhomogeneous Pillars and 'Ceiling' Rock Using the Photoelastic Method." The models were made from a gelatine-glycerine base—Igdantine—which could be used for making stratified models of any desired dimension of different elastic constants. The model studies showed that the stressed condition of the roof in the working room was dependent upon its thickness, the relationship of the modulus of elasticity of the deposits to that of the adjacent strata, and the conditions pertaining at their contact surfaces. The author stressed that the presence of interlayers in the pillars caused changes in the stressed state of pillars such as could significantly lower their bearing capacity. The interlayers used in the model study had lower modulus of elasticity than the material used for making the pillars.

C—Rock Characteristics

The first paper in this group was given by T. Horibe and R. Kobayashi of Japan on " Physical and Mechanical Properties of Coal Measure Rocks under Tri-Axial Pressure," in which variations of different physical properties of rocks under tri-axial pressure was studied experimentally. Their experiments showed clear rupture planes on sandstone specimens at low confining pressures (0 to 30 kg./cm.^{2}) but at 60 kg./cm.^{2} confining pressure there were rupture planes which were not well defined. At high confining pressure (120 kg./cm.^{2}) the specimen flowed markedly, assuming a barrel-like shape and a network of faint lines (analogous to the Luder's lines in metals) appeared on the surface of the specimen. As the axial pressure was increased the specimen showed plastic deformation. The increase in the confining pressure on the specimen was associated with :—(i) An increase in the Young's modulus ; (ii) an increase in the compresive and tensile strength ; (iii) an increase in the regularity of the sheared surfaces in the double shear test ; (iv) a decrease in the Poisson's number ; (v) a decrease in the ratio of the compressive and tensile strengths, and (vi) a decrease of the " brittleness number " defined as the reciprocal of the strain at a maximum load.

A new method of testing the rock to destruction was described by M. M. Protodyakonov of the U.S.S.R. in the paper entitled " New Methods of Determining Mechanical Properties of Rocks." The conventional methods of determining the rock strengths involve the use of regular shaped specimens which are quite laborious to make. To overcome this difficulty the author developed a method of finding the compressive strength of rocks by crushing specimens of irregular shape. Results obtained from both regular and irregular shaped specimens were plotted in the form of histograms and the mean value was very close to each other. To obtain the same accuracy of the mean values the number of specimens tested had to be twice that of the regular shaped specimens. Tests were made on specimens of volumes ranging from 0·5 cm.^{3}. to 150 cm.^{3}. It was also stated that all the characteristics of the mechanical properties of rocks were correlated with one another. This correlation was closest between the rock mechanical properties of close physical nature—*e.g.*, the strength of the rocks in uniaxial and in bulk compression. The correlation between characteristics of different natures were less intimate. The author suggested the construction of rock strength scales in accordance with a geometric progression. Allowance for the variation of the rock strength characteristics and the acceptable number of tests should be given to determine the progression factor.

C. D. Pomeroy of the U.K. then described " Laboratory Experiments to Investigate the Effect of Overburden Pressure on Coal Ploughing." The experimental method consisted of making grooves in a block of coal which was clamped between two steel plates capable of exerting pressure up to 1,000 p.s.i. and was moved horizontally so that the coal was forced against a steel wedge the force on which could be measured by strain gauges. Grooves of different depths for

different clamping pressures were made in different coal blocks. The curves of mean peak grooving force and the lateral pressure showed that for a particular lateral pressure the value of mean peak grooving force increased as the depth of groove was increased. For a hard coal mean peak grooving force increased continuously with the lateral stress (500 p.s.i. maximum), but with soft coal it was found that the mean peak grooving force showed decrease after a certain lateral stress. It was stated that the cleat frequency and to some extent the cleat orientation dominated the forces required to groove the coal and that the effect of lateral pressure was dependent on both of these parameters. The importance of cleats in reducing peak grooving forces increased with depth of cut and decreased with lateral pressure. Further experiments showed a linear relationship between the frequency of main cleats and the mean peak grooving force. The effect of cleat frequency was found to be most marked when making deep cuts at low lateral pressure and this effect was reduced as the lateral pressure was increased. For all the nine different types of coal used in the experiment the increase in the lateral pressure from 50 p.s.i. to 500 p.s.i. was accompanied by an increase in the energy consumption. The author suggested that it would be better to extract coal either in the unstressed state or at a lateral stress which was sufficient to reduce the energy required to groove the coal.

An analytical paper was then presented by Josef Żnanski entitled " Criteria of the Gradual and Sudden Collapses of Surrounding Rock into Mining Excavations." Compression tests were carried out in the laboratory on samples of coal, sandstone, and shale (Carboniferous rocks). The tests on specimens placed between rigid surfaces of steel showed that the friction at the contact surfaces restrained the lateral displacement of points on the ends. The pressure which was thus transformed was non-uniform and reached its highest value on the circumference of the sample (cylindrical specimen) and fell off towards the middle. This was responsible for the inhomogeneous state of strain and deformation in the sample. Under uniaxial compression the rocks of uniform small grain showed splitting of the specimen across planes parallel with the direction of compression axis, but specimens from a heterogeneous rock of irregular size distribution and uneven mineralogical structure showed a fracture with two cones with their apexes together. In the second set of tests the friction at the contact surfaces was eliminated by compressing the specimen between smooth non-rigid surfaces coated with paraffin wax. According to the author this method gave the real strength of the rock. The specimen fractured along planes running almost through the axis of the specimen. In this case the tensile stress was found to be almost equal to the rupture stress of the samples with friction at their end surfaces. In the third series of tests the ends of the specimens were covered with wax and the crushing strength was found to be lower than the real value because of the outward flow of wax which exerted a traction effect on the ends of the specimen. All these tests showed that under certain conditions of compression and at a certain load the stresses and strains depended on the geometrical and material condition of the samples. By analysing factors such as structure, the deformation curve, and the rate of deformation of the trip load, and the deformation the author was able to establish correspondence between structural models and the rocks studied. It was mentioned that the work of compression which was applied to the specimens was either transformed into elastic potential energy or became dispersed as a result of inelastic deformation. The distribution and the value of the elastic energy was found to be dependent on :—(*a*) The shape of the specimen, (*b*) the absolute value of the dimensions of the specimen and their relative proportions, and (*c*) the condition of compression on their end faces.

The compressive strength of the specimens in the form of plates (the height being a fraction of the lateral dimension) was found to be 2 to 3 times higher than that of the cubic samples. The author then mentioned some examples of the actual mining which could be interpretated in conjunction with the results of the laboratory work. Thus the conditions which cause the movement of a seam in a continuous and gradual manner was compared with the compression of a sample with the ends coated with paraffin wax. The seams liable to bumps were compared with the specimens which were loaded between rigid rough or smooth surfaces. From this analogy the author explained the conditions which may cause a seam to move in a continuous and gradual manner and also the factors necessary for bumps to occur in a seam.

The last paper in this group, entitled "A Laboratory and Underground Study of the Bearing Capacity of Mine Floors," was given by J. D. Jenkins of the U.K. The bearing capacity of the mine floor is the fundamental factor in any system of strata control. The author carried out investigations into the failure of the floors of the coal seams under the loads imposed by face supports. His theoretical and experimental analysis shows that the relationship between the bearing capacity and the base size for mine floors may be of the form $q \propto d^m$, where q is the bearing capacity and d is the diameter of the prop base. The theoretical values of m are as follows: + 1 for cohesionless floors; 0 for perfectly plastic and soft elastic floors; 0·5 for very brittle floors, and − 1 for hard floors overlying softer materials.

Square bases were found in general to reduce the bearing capacity by up to 15% compared with the circular base. The triangular base produced slightly larger reductions than the square bases. Relationship between the bearing capacity and the size of the base is most advantageous when fairly uniform loading is achieved. This can be attained either by using soft material between the prop and the floor or by shaping the prop base in such a way that contact over the whole of its surface is only achieved after some deformation of the floor has taken place. Investigations with dome-shaped bases showed a lower rather than a higher bearing capacity when compared with flat base. The author attributes this to the uneven nature of the floor which did not permit the uniform loading to be achieved before a high concentration of stress had been built up to some point or other. As expected the effect of water on the mine floor reduced the bearing capacity for a given size of base.

D—Underground Measuring Methods and Equipment

The first paper in this group, by H. G. Denkhaus and F. G. Hill, reviewed "Conditions of the Ground Around Excavations in Hard Rock at Great Depth." The authors gave a brief review of the research carried out in the deep-level (4,000 ft. to 10,000 ft.) gold mines of the Witwatersrand in South Africa. Although excavations at these depths were found to be surrounded by a zone of fractured rock it has not yet been possible to define the shape and size of these zones. The author stresses that it is necessary to study the configuration of these fracture zones to understand the phenomena of rock-bursts and the strata movement in deep mining in South Africa. The methods used to study this included underground observations and measurements and also theoretical study and laboratory work. At a mine in the central Witwatersrand the following *in situ* observations were made:—

(*a*) The fracture plane in the footwall of an excavation started in an almost vertical direction and then curved away from the solid face at an angle of about 55°.

(*b*) The fracture planes in the hanging-wall were found generally to dip towards the solid face at an angle of approximately 75° to 80°.

(*c*) The foot-wall fracture zone was generally found to be less extensive than the hanging-wall fracture zone.

To measure the extent of the fracture zones around the excavations the following three methods were used:—

(*a*) Visual examination of the bore-holes in the rock face by means of a 'light source' and mirror system. The fracture extended to the order of 15 ft. to 20 ft. in the wall.

(*b*) Examination of diamond-drill cores.

(*c*) The propagation of ultrasonic waves through rock. This method consists in inserting a reflectoscope in the hole drilled in the rock *in situ*. The reflectoscope acts as a transmitter of acoustic pulses and also as a receiver for the pulses which are reflected from the surfaces of the fissured rocks. Thus, in a highly fractured ground more reflected energy will be received compared to that in less fractured ground or in a solid unbroken ground. This method was found to be effective within a radius of about 5 ft. around the hole.

Investigation by these methods indicate that the fracture planes become more widely spaced towards the solid ground and the boundary of the fracture zone is not necessarily a smooth surface. Measurements of the stresses ahead of the working face were taken by registering the changes in the diameter of the hole. These results indicated that a zone of high stress existed at some 15 ft. to 30 ft. ahead of the face.

The authors state that the results of the stress analysis obtained from photo-elastic

investigation could also be used to get a general picture of the shape and size of the fracture zone developing around an excavation if the stress conditions under which failure of rock occurred were known. In a photo-elastic model of a rectangular opening a crack was made at the centre of its roof and the stress analysis showed that for short cracks tensile stress at the tip of the crack increased rapidly with increasing crack length. The tensile stress then reached a maximum and decreased with increasing crack length, but it showed appreciable value even when the length of the crack became equal to the width of the opening. The authors thought that, depending upon the strength of the rock, further propagation of the crack was to be expected. A mention of the ground movement in the stope area was also made.

The second paper entitled " Investigations of Rock-Pressure Variations around Underground Long-wall Workings " was presented by Ko Suzuki of Japan. The author used two types of load cells—*viz.*, " Bullet " type and Tongue type load cell—to measure the stress changes occurring ahead of advancing long-wall coal faces. The " Bullet " type load cell was made of light alloys (with physical constants similar to those of the rock) and strain gauges were stuck on its inside surface. This cell could be used to determine the principal directions of the stresses acting on the cell. In the tongue type load cell the pressure acts on a tongue which is filled with silicone oil or glycerine. The hydraulic pressure is transferred to a disc on which are mounted strain gauges. The *in situ* measurements revealed that changes of stresses could be detected about 100 m. ahead of the coal face. Strata conditions seemed to affect the measurements of the changes in stress.

Measurements made by using strain gauge prop load cells showed a maximum load of 25 tons on steel props used on the long-wall face.

Measurement of the load on steel arches set in the gate road showed that the load acting on the dip side was higher than that working on the rise side. The effect of the long-wall working on the arched support was detected 50 m. in advance in the gate road.

The development of the uniaxial and biaxial stress meters in Canada was dealt with by A. N. May in his paper entitled " Instruments to Measure the Stress Conditions Existing in the Rocks Surrounding Underground Openings." The stress meter design was based on the principle that if the ratio of the elastic modulus of the stress meter to that of the rock surrounding it was greater than four then the value of the stress given by the stress meter would be almost independent of the elastic constants of the rock. The uniaxial stress meter consists of a cylindrical steel body in the middle of which there is a flat recess containing hydraulic fluid. The pressure on the cylindrical body is taken up by the hydraulic fluid which acts against a diaphragm on which electrical resistance strain gauges are mounted. The pre-setting was achieved by driving the stress meter in a tapered sleeve which was placed in the diamond-drilled bore-hole. The *in situ* tests carried out in an iron-ore mine showed the stress meters to be quite stable.

There was found a close agreement between the theoretical analysis and the laboratory measurements on the principle of determining the biaxial stress by measuring the change in the internal diameter of a hollow cylinder which was inserted in a bore-hole drilled in a rock specimen.

Another paper of this group dealing with the development of the uniaxial stress meter was presented by E. L. J. Potts and N. Tomlin of the U.K. in a paper entitled " Investigations into the Measurement of Rock Pressures in the Mine and in the Laboratory." This stress meter is very similar to that described in the previous paper by May. The diaphragm construction and the method of insertion in the hole are different. The stress meter is used in conjunction with a cylindrical conical slotted steel sleeve which is provided with an extended section. This section is internally screwed to take a shear pin head which is provided with four lugs and is keyed into slots in a hydraulic ram cylinder adaptor. The hydraulic ram provides a setting force to the stress meter and this can be varied according to the shear strength of the pins used. The laboratory tests showed that the effect of increasing the insertion force was to increase the stress sensitivity. The *in situ* pressure measurement at a coal face showed a high pressure zone about 10 ft. ahead of the face but the stress on the coal immediately in front of the face was very small. The stress meter is also in use in the Kolar gold mines in India and in a salt mine in Cheshire.

E. R. Leeman of South Africa then dealt with the measurement of the change in the diametral deformation of a hole *in situ* in the

gold mines of South Africa in a paper entitled " Measurement of Stress in Abutments at Depth." He derived mathematical equations connecting the diametral deformation of the hole with the stress on the material, its Poisson's ratio, and the diameter of the hole. These equations were used to evaluate the changes in stress from the *in situ* measurement of the change in the diameter of the bore-hole. Along with the bore-hole deformation meters made by Maihak of Germany two other types of instruments were also used. These instruments (strain cells) were designed for $1\frac{1}{2}$ in. diameter hole and they could measure or record the changes in the diameter of a bore-hole in two directions at right angles to each other. One of these strain cells used electrical resistance strain gauges which were cemented upon circular rings as the measuring element, while the other strain cell used linear variable differential transformers. These cells could measure changes in diameter of 1×10^{-5} in. over a range of 0·1 in. The *in situ* measurements showed that at a distance of about 25 ft. ahead of the face of the stope the stress began to increase until as close as about 12 ft. ahead of the face the strain cells ceased to function probably due to a collapse of the bore-holes themselves. The effect of blasting at the stope face caused an increase in the vertical normal stress ahead of the stope face and this was detected up to 50 ft. ahead of the face. There was no build up of stress or any other warning preceding the occurrence of rock bursts.

The last paper in this group entitled " Study of the Influence of a Moving Face on a Cross-Cut Driven Below it " was presented by H. van Duyse, of Belgium. In it the author described the research programme to be carried out in a coal mine. The main points in the programme are as follows :—

(1) Convergence measurement of a large number of pairs of plugs which will be placed in the various cross-cuts and face roads.

(2) The displacements of a series of markers placed in the various cross-cuts and face roads will be measured.

(3) Bed separation will be measured.

(4) Static loads and the stress induced by the moving face in the rings of concrete blocks in the various cuts and in the concrete at fork roads will be measured by strain gauges and by sticking sheets with photo-elastic coatings.

(5) The stress changes occurring ahead of the coal face will be measured by stress meters.

(6) The stress in the stowing zone will be measured by means of dynamometric capsules and flat jacks.

In an annexe the author described in detail the method of measuring stress *in situ* by using a photo-elastic method.

E—Observations and Measurements in Roadways

The first paper in this group, entitled " Measuring the Loads on Roadway Supports by Means of Strain Gauges," was delivered by F. J. M. de Reeper and F. P. Bruens of Denmark. The authors described the measurements taken at the roadhead of a supply gate road which was serving a 180 m. long-wall face. The face was supported by articulated bars and Titan props having an average initial yield resistance of 30 metric tons. A multiplough was used on the coal face giving an advance of 3·25 m. per day. The investigations were carried out in the following three parts :—

(*a*) Ten alternate roadway supports consisting of H-section props and bars were provided with strain gauges to measure the stress changes. Strain gauges were stuck across two sections on the bar and along one section on each prop.

(*b*) To measure the convergence and movements measuring points were provided in the roof, floor, and sides of the roadway.

(*c*) On the goaf side of the roadway behind the coal face hydraulic measuring capsules were placed on the floor underneath the four corners of the timber chocks—six in all. Measuring hydraulic capsules were also placed underneath the strong timber props which were set in the goaf and only 1 m. from the timber chocks.

It should be noted that at the time of starting the experiment the roadhead was 18 m. ahead of the coal face. The main points derived from the above measurements are as follows :—

(1) In front of the coal face the bending stress was negligible on the bars. This was due to the fact that the initial stress compressed the padding which was placed between the roof and the bar. On the other hand, the back falling behind the props was rigid and was resting against the props from the very start. This gave an appreciable bending stress on the props. As the coal face advanced the bending stress on the bars

showed a continuous even increase, but on the props it was greater at the beginning compared to the value obtained when the face had advanced.

(2) No correlation was found between the bending stresses on the various measuring supports taken at a similar distance behind the coal face and the convergence data obtained in the respective measuring sections.

(3) There was not found any correlation between the convergences and loads of the various timber chocks measured at a similar distance behind the coal face. The packing material inside the chocks did not seem to take any appreciable load until the chock convergence exceeded about 20%.

(4) No correlation could be found between the bending stress (on the props and bars) and the loads or convergences of the nearest timber chock.

(5) The strong timber props set in the goaf seemed to carry very high loads—*e.g.*, three props carried 50 tons compared to 15 tons by one chock. These props initiated a break line which ran along their contact in the roof.

P. Stassen and R. Liegeois of Belgium then discussed the " Differing Behaviour of a Type of Rock in a Gate Road as Affected by the Methods of Driving and Supporting." In this paper the authors have shown that the behaviour of the rock in the gate roads of a long-wall face is greatly influenced by the driving and supporting methods. Observations were made in gate roads in two collieries and the authors reached the following conclusions (applicable to soft rocks in deep mines) :—

(*a*) The long-wall coal face is preceded by a high stress zone which may cause fracture of the roof strata if a gate road is driven in advance of the face.

(*b*) The roof strata in a roadway should be allowed to subside *en bloc* at the same time as the adjacent strata so that compactness of the strata could be maintained.

(*c*) On soft floors the penetration of the supports should be prevented. This causes the floor to heave and also the roof is subjected to sagging and fracturing. A very rigid support is also not recommended as this may prevent uniform subsidence of the roof. In difficult cases protection of roof and floor may be achieved by making use of stowing and debris-packed wooden chocks.

(*d*) The roof should be allowed to subside slowly. This will help to preserve the solid strata both longitudinally and transversely.

An analytical paper entitled " Prediction of Rock Movement in Roadways " was presented by B. Schwarz of France, in which the possibility of predicting the strata movement in roadways, based on results obtained from underground workings, was discussed. The author took into account a number of variable factors which influenced the strata movement.

In a roadway uninfluenced by any working there was found a linear relationship between the convergence (measured between two plugs fixed between the roof and floor) and the logarithm of time. This made it possible to predict convergence for any future period just by making measurements in the first few weeks. There was found a linear relationship between the convergence measured 14 days after driving and that measured 229 days after. Thus if a section of roadway shows high convergence values it should be interpreted that there is likely to be trouble in future and it is possible to predict the time when this will occur.

A linear relationship has been obtained between the convergence values between the plugs and absolute value of the convergence of the roof plug. Plugs inserted to different depths in the roof showed a linear relationship of the different convergence values measured at different times. As the depth of the plugs in the roof was increased the bed separation was found to be decreasing. No roof convergence was measured in the roof plugs which were fixed 4 m. to 6 m. above the immediate roof. The author stresses that it is this thickness of the strata which is sensitive to expansion and it follows a logarithmic law as a function of time.

It was found that when a face approaches the plugs which are situated in a roadway the convergence between the plugs at first increases at a high rate and after the face has passed the rate of convergence decreases. The point of inflexion of such a curve was found to be situated 1 m. to 10 m. or even 20 m. beyond the position when the face passes the plugs. The ratio of the convergence values 30 m. before the face had reached the plugs to that when face had passed 50 m. beyond was found to give a constant ratio. The author has also shown that it is possible to predict convergence in a roadway affected by a face even without a measurement.

The author concluded that it was now possible, by making a few measurements

during driving or by simple data requiring no measurements (roadways influenced by faces) to make a long term prediction of rock movement at any point, at any face, and at any moment.

A fourth paper was then delivered by F. Schuermann of West Germany. It was entitled " Measures Against the Relaxation Movements Occurring in Roadway Walls." After giving examples of some loading and deformation measurements the author stated that the support in a gate road or drift was mainly loaded by the weight of the broken rock lying between the support itself and the tension ellipse which formed around the roadway. The supports which are set without initial stressing are loaded only as a result of the relaxation movements on the part of the rock surrounding the roadway. The effectiveness of the support depends mainly on whether it can offer high resistance quickly and evenly. The cohesion of the rock in the roadway wall is lost to a greater or lesser depth in cases where the relaxation of the surrounding rock is allowed to occur although the roadway is provided with normal supports. The immediate rock " casing " of the roadway is then in the broken state with a markedly reduced bearing capacity. Its weight loads the support and in this way reduces the resistance which is to be offered by this support to further relaxation movements.

The author suggests that these relaxation movements can be reduced by installing strata bolting. Numerous examples were given of gate roads supported by multi-section sliding steel arches where the unsatisfactory strata condition (high convergence, distortion of the supports, high floor lift, etc.) was improved by installing strata bolts in conjunction with the conventional supports. In soft finely-stratified rock the expansion bolts were not found to give sufficient nominal load-bearing capacity. Although concrete bolts were found to be satisfactory the hardening period of 8 hours to 24 hours created operational difficulties. A mixture of polyester resin with quartz sand and some hardening agent was found to give a setting time of 20 min. to 30 min. and after this time the bolt can be tensioned. The degree of " purchase " was found to be 1·2 tons to 1·7 tons per cm., but this figure fell up to 50% in damp bore-holes. The author stated that in stone drives supplementary bolts had been under test for over a year to reduce extraction effects and to increase the standing time of supports. Numerous sketches were illustrated to show the disposition of strata bolts in gate-roads serving seams with inclinations varying from 0° to 90°.

The paper entitled " Roof-Bolting in Roadways " was delivered by R. Cardon and R. Buisson of France. The authors deal with the underground measurements in roadways supported by roof bolts, the tests including measurements of convergence, deformations, and expansion of the strata around the roadway.

A comparison of the frame supports with those of strata bolts was carried out in a roadway which was divided in four sections of lengths 30 m., 40 m., 40 m., and 30 m. The first and the third sections were supported with roof bolts, while the second and fourth sections were fitted with T.H. frame supports. The measurements showed no difference in the appearance of convergence curves in relation to the time for the pairs of plugs in both the framed and bolted sections, but the bolted sections showed less pronounced convergence. However, this is not always true. In one case where there was considerable yield in the coal in the roadway walls there was observed an increase in the movements in the bolted sections compared to that in the framed section.

In order to know in advance if there is any roof fall likely to occur in a bolted roadway measuring points were installed every 30 m. just after the driving work. It was found that an anomaly in the development of the convergence or in the curve of the roof was always associated with the deterioration of the strata condition in the roadway and, therefore, steps should be taken to counteract this. The movement of the side walls was found to be very unfavourable to the stability of a bolted roadway and in such conditions the sides should be consolidated by bolting and appropriate lagging. As these anomalies can be discovered after a minimum period of about 15 days it is possible to find out whether or not it is advisable to continue with bolting.

The relationship between convergence and the distance of the measuring section from an approaching face was found to resemble an S curve. This means that as the working face approaches the measuring section the rate of convergence increases and after the face has passed the rate of increase decreases. Actually the point of inflexion of the curve (in one case) occurred after the face had gone past the

measuring point by 8·8 m. and 4 m. in the bolted section and the frame section respectively.

The expansion of the strata around the roadway was measured by inserting plugs in the roof to different depths. There was found a certain effect of cohesion in the lower beds up to a few metres after the passage of the face. This effect disappeared after the face had passed more than about 10 m. beyond.

Convergence was also measured between the time when the face passed right above each measuring station and the moment when it reached 50 m. beyond them. The convergence was found to be greater in the bolted sections compared to the section supported by frame supports. After the face had passed there was found a zone with high expansion which affected the first bed on the solid rib side and increased in the upper beds of the face side—*i.e.*, goaf side. Thus it seems that the bolts installed on the rib side will be under high strain.

The authors mention a case where out of 90 roof-bolt breakages in a roadway 65 came from the rib side, 24 from the middle, and one from the face side. In the end the authors conclude that the roof bolting is of particular value in re-treating workings.

The last paper in this group was presented by J. Stuffken, of the Netherlands, on the subject of " The Influence of the Depth and Other Factors on the Behaviour of the Rock Pressure Around Roadways and on the Resulting Maintenance." This work is mainly based on a number of observations obtained from the repair work (maintenance) in the roadways. The author deals mainly with the influence of different factors—*e.g.*, thickness of the seam worked, topographical depth, geological depth, and the life of the roadway —on the behaviour of the rock pressure. It was stated that the maintenance required in a road depended on the following factors :—

(*a*) *Local factors.*—(I) Nature of the immediate and the remote surrounding rock ; (II) depth of the roadway, and (III) dip and the thickness of the seam worked.

(*b*) *Technical factors.*—(I) Type of support and lining ; (II) method of coal winning (caving or stowing) ; (III) type of roadside packs ; (IV) rate of advance of the face and life of the road, and (V) demands for the dimensions of the road.

(*c*) *Personal factors.*—(I) Demands for preventive maintenance ; (II) demands for the finishing of the timbering and the roadway supports, and (III) personal opinions about the road condition.

To derive numerical and graphical relationship the author has expressed maintenance in terms of the number of man shifts per metre of the roadway. A number of empirical equations were derived to show the relationship between the following : (*a*) Number of maintenance shifts ; (*b*) topographical depth ; (*c*) geological depth ; (*d*) seam thickness ; (*e*) nett volatile matter content of the coal, and (*f*) life of the road.

These equations have shown that the maintenance in the underground working increased with the increase of the topographical depth of the working, but it decreased with an increase in the geological depth. It was also shown that the increase in the maintenance with increasing topographical depth was four times as much as the decrease in maintenance with increasing geological depth.

F—Observations and Measurements in Faces

The first paper in this group was by V. Sibek of Czechoslovakia on the subject of " Rock Pressure and Deformation of Tertiary Rock During Excavation of Thick Brown-Coal Seams by Long-wall Method in Strips with Caving." The author described the investigations in two coal mines in which the method of extraction consisted of long-wall workings in thick seams. In the Ziska colliery the method consisted of extracting two strips simultaneously with a short interval between the two. In the Ludmila colliery it was planned to extract the second strip (bottom section) a long time (about one year) after the first strip. The following observations and measurements were made :—

(*a*) *At the coal face.*—(I) Resistance and character of the supports ; (II) convergence of floor and roof ; (III) load-bearing capacity of the floor in relation to the effect of time, and (IV) the effect of using oak chocks.

(*b*) *In the gate roads.*—Convergence of roof and floor in relation to face advance.

(*c*) *In the caved area*—(I) Increase in the load of caved rock ; (II) deformation of the floor, and (III) temperature in relation to face advance.

The main conclusions from these investigations are as follows :—

(*a*) In workings with weak floors care should be taken to construct the base of such a shape and dimension that the force exerted

by the support on the floor is less than the load bearing capacity of the floor.

(*b*) On the goaf side of the coal face the roof subsidence must not exceed 1 cm. to 15 cm.

(*c*) The load-bearing capacity of the floor and its resistance to penetration decreases with time.

It is, therefore, necessary to choose an extraction method which will allow a daily advance of the face by 2 m. to 4 m. The floor penetration on the goaf side of the face can be minimized or prevented by using denser supports. The author stresses the need for pre-loading of supports in such cases. He recommends that if chocks are to be used they should be only mechanized ones of 60 tons to 100 tons carrying capacity with a setting load of 10 tons to 30 tons.

The effect of stopping the face advance for a few days was found to cause an increase in the prop resistance near the face as well as on the goaf side supports.

(*d*) A comparison between the shapes of prop foot plates showed that the load-bearing capacity and the resistance to penetration was higher for disc-shaped plates compared to the square plates.

(*e*) The immediate roof strata in the caved waste was found to collapse to a distance of about 7·5 m. behind the face. After this the upper roof strata began to subside. At a distance of about 25 m. behind the face (after a one month interval) the pressure of the caved strata produced about 80% of the cover load on the floor.

(*f*) The permanent deformation of the floor in the caved area was found to amount to 20% to 30% of the maximum deformation of the floor near the caved zone at the face. The load brought upon the floor by the caved rock can be deduced from the deformation of the floor in the caved area.

(*g*) The observations made in the underlying rock behind the face showed the presence of following zones :—

(I) A zone of relaxation at a distance of 7 m. to 12 m. behind the face.

(II) A zone of gradual compression from a distance of 7 m. to 12 m. behind the face.

(III) A zone of normal full load which could be distinguished by the stabilization of the rock in the caved area.

(*h*) In the gate roads of the first strip and ahead of the coal face the following zones were found :—

(I) A zone of normal deformation up to a minimum distance of 70 m. ahead of the face.

(II) Up to a minimum distance of 15 m. ahead of the face there is a zone of increased deformation.

(*i*) The temperature in the goaf was found to be constant.

At the end the author states that these observations will be supplemented by photo-elastic models.

The second paper, by R. Dubois of France, was entitled, "The Various Factors Governing Face Convergence." In the third paper of group E Schwarz had shown the convergence between two plugs situated in the roadway by an S curve. In this article the author shows that a study of the daily convergence of a face covers only that portion of the S curve which lies at the point of inflection. The article mainly deals with the effect of rate of advance, the method of stowing, the thickness of the seam, and the support system on the magnitude of the daily convergence at the long-wall face.

Experimental investigations have shown a linear relationship between the convergence between two plugs at the face and the rate of face advance. The convergence was also found to be directly dependent on the seam thickness. The relationship between the convergence Cj, the rate of face advance Va, and the seam thickness W is expressed as :—

$$Cj = O{\cdot}356\ Va + 0{\cdot}340\ W - 32{\cdot}31$$

In most cases the difference between the actual and the calculated value of Cj was found to be under 30%, although in some cases it went up over 60%. It thus enables one to forecast the daily convergence of a face to a first approximation.

A comparison of the non-caved faces with those for the caved faces showed that (*a*) the convergence was less with hand packing ; (*b*) the convergence was even smaller with pneumatic stowing, and that (*c*) the convergence was smallest with hydraulic stowing. The influence of depth on the convergence was found to be very little. The length and the inclination of the face did not show any clear effect. The convergence of the surrounding strata seemed to effect the convergence measurements considerably. The hard strata seemed to give lower convergence than the softer ones. On faces with soft floor the use of base plates under props reduced the face convergence by as much as 30% to 40%.

The characteristic curves of the props was also found to affect the convergence. Props with rapid load-bearing capacity allowed

smaller convergence at the face. The author suggests that for hard strata it is better to use props with horizontal load-bearing capacity, the yield load being dependent on the hardness of the strata and the bearing surface of the prop.

The third paper, entitled " Experience Gained in the Application of the Theory of Dimensions for Determining Roof Displacements in Faces, Taking the Time Factor into Consideration," was delivered by K. B. Ruppeneit, of Moscow. By using the theory of dimensions the author has calculated the displacements (convergence) of the roof above the working face (U_o*) and at the end of the working area (U_o)—*i.e.*, along the goaf line.

To calculate U_o* the author assumes that it depends on :—

(I) The stress concentration in the solid rock ahead of the coal face, which is proportional to rh, where r is the volumetric weight of the roof rock and h is the depth of the working.

(II) The modulus of elasticity of the coal, E_o.

(III) The compression strength σ and the tensile strength H.

(IV) Seam thickness h_o.

On this basis the author shows that :—

$$U_o^* = A\frac{r.h_o h}{E_o}$$

A is a dimensionless coefficient to be determined from the results of pit observations.

To calculate U_o the author assumed that it depended on :—(I) r h ; (II) E the modulus of elasticity of the strata ; (III) the width of the supported area S ; (IV) U_o* ; and (V) the reaction of the supports P.

From the theory of dimension the author derived a general expression and then by applying the method of least squares he found :—

$$U_o = S\sqrt{\frac{1{\cdot}188}{E}(h-P)\left(1+\frac{t}{t_o}\right)+\left(\frac{6{\cdot}65\ h\ h_o}{SE_o}\right)^2} - \frac{6{\cdot}65\ h\ h_o}{E_o}$$

Here t_o = the mean relaxation time.

There was found a close agreement between the calculated values for the roof displacement and those obtained from 137 faces in 29 pits.

The fourth paper was delivered by W. H. N. Carter, of the U.K., and is entitled, " A Review of Strata Control Experience in Long-Wall Working in Great Britain." The author discusses strata control investigations made regarding ground movements, fractures, and supports at the face, behind it, and ahead of the coal face.

The observations of movement were made in roadways driven ahead of the coal face. Greater disturbance ahead of the face is experienced where the ground pressures are high and the strata near the seam is weak. Movements due to workings have been recorded up to 216 ft. in advance and fracture cleavages have been found 87 ft. ahead. Secondary fracture cleavages are also formed. There is less fracturing and movement in shallower mines and stronger strata. On the short face, or close to a rib side on a long-wall face, fractures are less marked and are formed less far ahead.

From the records of surface subsidence it appears that the ground forming the rib sides carries part of the load of the beds, which in the middle of a long face abuts on the roof, coal, and floor, ahead of the face.

At the coal face the strata around the face is subjected to shearing forces which tend to divide the roof into blocks equal in width to the depth of cut. These shearing forces are stronger in harder rocks.

Behind the face, where pressure exceeds the strength of the beds, there is considerable movement of the floor or sides into the roads.

The author states that on long-wall faces far more supports are displaced than are broken. Precaution should be taken so that the prop is loaded through its axis.

Some of the power-operated supports tend to exert high resistance nearer the waste edge. There is occasionally a risk that the roof at the waste edge will break forward and this will result in the tilting of the bars and the cantilever resistance may fail. The author states that some weak roof would be best controlled by a system having the main resistance slightly nearer the face, with at the waste edge less rigid elements to help to preserve the roof over the main supports.

During some part of the cycle of operation at the coal face the distance between the face and the nearest supported area is likely to be maximum. In strongly-bedded rocks bed separation might occur near and over the coal face. The removal of the power-operated supports in close succession may result in more sagging and bed separation. The advancing and resetting of these supports will tend to reduce the bed separation but will cause fractures due to high setting loads.

It is therefore better to use supports that can offer more even resistance across the coal face—*e.g.*, the system in which only half of the supports are removed in the one series of operations.

The fifth and the last paper in this group was delivered by M. Berecki and A. Salustowicz, of Poland, on " Experimental Work in the Field of Rock Mechanics." In this the authors reviewed the work done in Poland in connexion with strata control. The paper is mainly concerned with the theoretical and laboratory work based on the assumption that the rock is a continuous (plastic) medium. *In situ* measurements were also carried out and included the following :—

(*a*) Rock pressure measurement ahead of the coal seam and also the goaf area.

(*b*) Measurement of support loads on long-wall faces.

(*c*) Measurement of support loads in gate roads.

(*d*) Survey measurements of movement of selected points in the roof and floor throughout the district under investigation and measurements of rock deformations around long-wall faces.

The state of stress inside the solid coal was measured by the " core release " and " isotope " methods.

In the core release method a strain gauge is attached to the far end of a suitably prepared bore-hole after which it is cored out. The deformation of the core is determined by measuring the change in the electrical resistance of the strain gauge.

The isotope method of stress measurement makes use of changes in secondary radiation occurring as a result of changes in the stress obtaining in the rock under investigation. The apparatus consists of a measuring probe which is a 1·1 m. long pipe with a Co^{60} radiation isotope fitted at one end and a Geiger-Muller counter at the other ; the latter transmits the pulses to the pulse converter.

In one case the measurements ahead of the coal face showed that an increase of rock pressure commenced at a distance of about 80 m. ahead of the face and the maximum pressure was recorded at a distance of about 15 m. from the face.

In another case there was steady growth of pressure up to the face, but in the vicinity of the face a considerable increase was noticed. Such a high development of pressure was attributed to a high degree of cohesion of the seam. The maximum compression of the seam was found to be less than 5% of the seam thickness.

The underground tests were supplemented by tests on rock models.

The authors stress the need to investigate the rheological properties of rock in the laboratory in order to assess the part played by time in rock mechanics problems. A considerable amount of work has been done on this problem in Poland.

The authors state that rock-bursts can be dealt with by relieving the particular seam from pressure by extracting an adjacent seam above or below the seam concerned. Rock-bursts can also be prevented by adopting a system of winning and development capable of preventing high pressure concentration on the faces.[1]

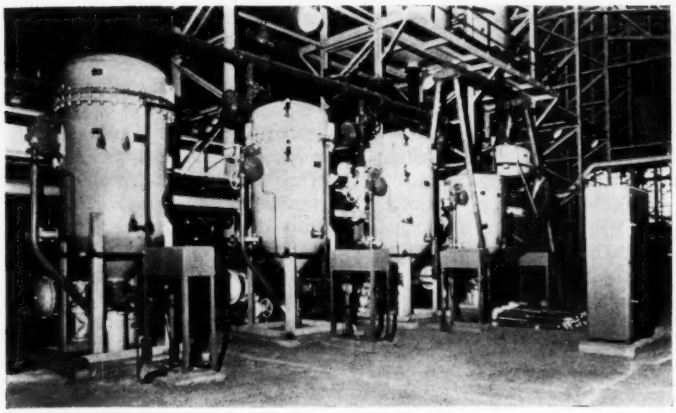
Ore-Dressing Notes

(1) *Dense-Media Separation.*

Processed Aggregates

Beneficiation of gravel required for concrete aggregates was first used on a commercial scale in 1948, according to an article by D. W. Jenkinson,[2] and now there are 28 plants using dense media for the process in North America. They deal typically with gravels containing a high percentage of undesirable material associated with their deposition from glaciers and with work where the concrete structure will be exposed to frequent cycles of freezing and thawing. An aggregate of softish stone is now widely recognized as prone to early failure, but " hard " stones can also lead to trouble if they are of the type called " absorbent " by the industry—that is, if they pick up moisture and then disintegrate through freezing. Specifications defining the qualities which must be met by coarse aggregates vary considerably, but they usually limit the percentage of *deleterious* stones and/or the overall deleterious content. The term " deleterious " may include organic material, chert, clay, soft particles, hard but absorbent stones, and shale. These are determined by inspection and the looseness of specifications makes it difficult for producers to handle the question of specific percentages of adulterant in terms of specific gravity. To remove coal,

[1] *To be concluded.*
[2] *Min. Engg.*, July, 1960.



Stellar Filter Units in the E.R.P.M. Mill.

shale, and organic detritus is a simple matter. Chert and ferruginous matter must, however, be dealt with by a very sharp cut in the density of the separating bath, combined with vigilant inspection by the process operator.

(2) *Handling.*

Transport by Pipeline

Over the past few decades the use of gravity and of pumps to move fluids thriftily has extended from its original fields of application until to-day ore pulps and relatively large lumpy material are handled smoothly over long distances. Recent studies have reviewed the transport of rock salt in saturated brine as well as limestone, sand, ore, lignite, and slurried coal in water for distances varying between 30 and 600 miles. Economic factors concerned either with adequacy of supply or the market have generally been most important, the technical problems being less in doubt.

Pipeline transportation has two basic advantages—low operating costs in terms of labour and material and no empty containers to return or dispose of. In general a pipeline scores over barges, rail, and trucking only when large quantities, long distances, high load factor, and long working life are assured. Design of a slurry pipeline is simple and depends on the power needed to move the material through the system, the elements being topography, slurry density, and friction at the required velocity and distance between boosting stations depending on the maximum pressure developed at the pump discharge and in the pipeline. Large lumps of moderate specific gravity can be moved short distances and smaller sizes further by using intermediate stages.

Records of pipeline transport of solids begin in the late 1850s in Californian placer mining, but hydraulic lifts using pressure jets in venturi systems were also used to raise gravels anywhere up to 55 ft., a method which spread to gravel mining in Malaya, Swaziland, and Nigeria. The relative inefficiency of conversion of power was not a factor, as hydraulic water was plentiful. The earliest U.S. patent (in 1889 by W. C. Andrews) called for delivery of fine coal from pithead to distant cities and allowed for crushing down to convenient size. It was not taken up, nor was something similar by W. T. Donnelly in 1904. In 1914 G. G. Bell made the first known commercial use of the principle to move coal from Thames barges to his boiler plant, 1,500 ft. distant, being thus able to avoid problems imposed by intervening streets and buildings. His more ambitious project, the transport of coal 130 miles from the Midlands, was dropped. Three systems were proposed in America in 1921 for distances up to 320 miles, but failed to compare favourably with rail transport at that time, terminal storage to smooth out seasonal fluctuation of demand being a factor. Various other small schemes were operated in the 20's and 30's for moving sludge, ashes, and coal-washery refuse for short distances, but in 1934 a 15-mile cast-iron pipeline started work in Louisiana, to move salt in saturated brine, and this still works. A feasibility study for a similar 55-mile line was made in 1937 and then pigeon-holed owing to cuts in railway rates for handling this material, but the project has now been revived. In the

phosphate industry there are now 20 installations handling between them 30,000,000 tons annually, mostly in 16 in. diameter spiral-welded steel pipelines with runs from 1 to 5 miles. A typical loading is 600 tons per hour of matrix with 7,000 gals. per min. of water at a flow-rate of 15 ft. per sec. and a solid/liquid ratio between 20% and 40%. A 10-mile pipeline built in 1950 for handling a clay slurry still works in Georgia, having one booster station. International Nickel started pumping its nickel-copper concentrates 7½ miles, and its tailings 2 miles further, on a down-slope of 1% at 5 to 6 ft. per sec. with solids concentration up to 50% in 1951.

In the past few years pipeline transport has steadily increased in volume, variety, and distance handled. One example is the gilsonite deposit where 50 tons per hour are pumped 72 miles over a mountain range from Utah to Colorado. Three types of pump are used, starting with a vertical sump pump in the mine, continuing with five centrifugal pumps in series, which deliver to a preparation plant, and finally a high-pressure plunger system for the 72 miles to the refinery. Among the more ambitious projects now under consideration are the transport of wheat from the Canadian prairie provinces to the Great Lakes and of wood chips in water slurry with hot chemical treatment *en route*.

(3) *Comminution.*

Automatic Pebble Feed

In pebble milling as practised ahead of cyanidation the loading is governed by mine production, pebble addition being adjusted so as to maintain the maximum draft of power by the tube-mill. Since the aim is not to maintain a prescribed mesh-of-grind but to apply maximum comminution to a changing volume of ore the adjustment of the percentage of crushing bodies in the load is an important factor in maintaining peak performance. Pebbles (unlike steel balls) wear quickly and must be frequently or even continuously replaced. Decrease in power draft from its maximum may be due to underloading the mill, to overloading, or to a change in the frictional grip between shell and crop load. The question whether the mill is underloaded or overloaded can be roughly settled by stopping feed in a ball-mill or by stopping the supply of new pebbles while maintaining a regular feed rate in a pebble-mill and noting the effect. Rise in power draft shows that the mill was overloaded. Because this reaction is slow to show results in the case of a pebble-loaded mill it is customary to work with a slight underload.

Discussing this background in a paper on automatic control of grinding media [1] J. E. Williamson notes that the first step in automatic control is to meter the power draft change. Since voltage is reasonably constant this grinding can work from the current and a signal generated at the current transformers and consisting of only a few milliamps can easily be rectified and smoothed. With the direction of power change automatically noted a controlling device for regulating input of pebbles becomes possible. This calls for the use of a self-balancing bridge which receives the smoothed signal. " Hunting " does not occur, since, as soon as the pebble load increases beyond the point of maximum out-of-balance of the mill, the direction of signal current is reversed and supply is cut off until the system has ground itself down to a determined point. This calls for a period on the rising side when the controller cannot stop the feed and one when overload is being ground down during which the pebble supply cannot be restarted. The cycle becomes (1) a sensing period, during which pebble feed is on and cannot be interrupted by the controller, and (2) a control period during which sensing continues, but during which a decreasing power signal can arrest pebble feed. Once the feeder stops it then remains halted until the next sensing period begins.

These factors were the essence of the problem. Experimental work led to the use of a magnetic clutch which responded immediately to signals from the balancing bridge and thus threw the pebble feed either into or out of action. Prototype tests were made, using a 12 ft. by 16 ft. mill and unsorted pebbles in the range of 60 lb. to 1 lb. The time cycle was 2 min. 35 sec. with a 1-min. sensing period and after the fourth day of test and adjustment pebble feed was made automatic for three weeks. The device was then stripped and examined for wear. Later tests with the same mill used a more conventional size range of pebbles and a time cycle of 7½ min., including a 2-min. sensing period. The device was then standardized and duly set to work in full-scale mill operations.

Summarizing the considerations which affect automatic pebble control the author

[1] *J. S. Afr. Inst. Min. Metall.* Feb., 1960.

notes that, in general, installation should apply to existing plants with manual control and that feed arrangements may need modification. Any mechanical feeder will do, provided it is unlikely to choke and also that it maintains a consistent feed rate. Pan feeders, roll feeders, and vibrating feeders have all been successful under test. The lag between stopping the feeder and cessation of delivery must be considered in setting the sensing period. Installation of this control does not obviate the need for good design and shift supervision in other respects, since it regulates only the maximum loading. The feed rate must be correctly set for full advantage to be realized. This is achieved when feed is automatically stopped under normal running conditions for about one half of the total control period. In the tests made, using conventional primary pebbles in a 12 ft. by 16 ft. mill, an improved power draft of 35 h.p. above the manual figure of 845 h.p. was made and, with unsized pebbles, of 64 h.p. above 780 h.p. under manual control. There is a saving in supervision by the shiftsman and a secondary advantage is that less closely sized pebbles can be used as feed where the supply of coarser sizes in the ore is deficient.

Letter to the Editor

Coal in Borneo

Sir,—I regret that I have to point out that one item in the letter on North Borneo published on p. 230 of your October, 1960, issue is almost entirely erroneous. It has presumably stemmed from an article in the local Press, which was published after an interview with Mr. Wang Yaw Tung without any attempt at obtaining confirmation.

The company has, in fact, nothing but prospecting rights and the renewal of these for 1961 is now under consideration. The coalfield concerned was mined from 1904 to 1932. Remaining reserves, allowing for a barrier to be left against water in the old workings, are estimated at: Measured, 2,739,000 tons; Indicated, 1,472,000 tons; Inferred, 6,403,000 tons; Total, 10,614,000 tons. Samples of weathered coal from the area have been shown to have coking qualities and there is a market for coking coal in Japan and Taiwan. But before an efficient mine can be opened, it is necessary (*a*) to prove the indicated and inferred reserves by drilling, (*b*) to determine the distribution of mineable sections of the seam so that extraction can be properly planned, and (*c*) to test the coking properties of the unweathered coal. No significant start has yet been made on these investigations and there is no question of mining starting in the near future.

F. H. Fitch.

Geological Survey Department,
British Territories in Borneo,
Kuching, Sarawak.

December 8, 1960.

Engineering Log

The jet-flame principle has now been harnessed in a compact and portable form to the carving, shaping, and drilling of stone, the process being applicable to concrete, granite, or any tough rock. It can be used to shape monumental details, for building blocks, and to pierce or trim walls. The stone-shaping flame of the " Oxweld " torch, which packs 25 h.p. in a 4-in. jet with a temperature of 2,881° C, and weighs just over 7 lb., is 37 in. long. One assignment was the burning through of two 18-in. reinforced-concrete flood walls, which took 2½ min. This was with a variant, the powder lance, which uses oxygen and a metallic powder mixture burnt at the end of a consumable iron pipe. Here a working temperature of 4,450° C is reached. Among uses envisaged for this new tool are the opening of slag pockets, deskulling of ladles, and tapping of furnaces. Operation is claimed to be simple and easy for anyone trained on oxy-acetylene welding.

* * *

At the University of California a new film for filtering salt out of sea water has been designed. Invented by two research engineers it has numerous tiny pores which separate the brine from the potable water. The film was developed by mixing cellulose acetate with aqueous magnesium perchlorate solution and acetone and then casting the viscous mixture cold on a cold glass plate. After the casting the plate is placed in cold water and a film four thousandths of an inch thick is then stripped and shrunk slightly in hot water. The sea-water filter is made by mounting the

resulting membrane on either side of a porous metal disc and stacking any desired number of such discs in a frame press. The salt water to be processed is circulated through the multi-disc unit at a pressure of 1,500 lb. per sq. in., the purified water flowing out at the bottom of the unit. With the present membrane it has proved feasible to obtain 8 gal. of potable water per sq. in. of membrane per day in a single filtering of brine with a 5·25% salt concentration—a much higher concentration of salt than is found in ordinary sea-water.[1]

* * *

A Frenchman, Nicholas Appert, succeeded in 1810 in conserving foods and a patent was registered for the use of tin containers in preserving them. A year later a Bermondsey factory went to work and by 1823 canneries were operating in America. The year just past marks the 150th anniversary of a business which to-day has an annual output of 50,000,000 cans, some 10% of the Western World's food being retailed in tin containers.

* * *

Columbium alloys containing tungsten and titanium combine oxidation resistance to 2,550° F. (1,399° C.) with good mechanical properties, while those containing aluminum and vanadium permit a hundredfold reduction in the oxidation rate of pure columbium and at the same time retain its inherent low neutron cross-section and improve its mechanical properties. In addition a programme aimed at accumulating the necessary background information on refractory metals for the development of a columbium-tungsten-tantalum alloy applicable at temperatures up to 3,500° F. (1,928° C.) is being undertaken by the Union Carbide Corporation in co-operation with the U.S. Air Force, while vanadium-base alloys containing 20% to 50% columbium, which show good high-temperature strength, good corrosion-resistance in both oxidizing and reducing environments, and fabricability by conventional hot-working techniques in air, are also being investigated.

* * *

The Soviet Union believes that an iron-ore deposit in European Russia, some 300 miles south-west of Moscow, may more than double the known reserve of high-grade ore. It lies in the Kursk magnetic anomaly, where compass aberrations have been known since 1784 and the deposit lies at a depth of 3,000 ft. So far 100 test holes have indicated that 30,000 million tons of magnetite, comparing favourably with Sweden's high-grade ore, exist. Mining has begun and is expected to reach 36,000,000 tons annually by 1965.

* * *

As man approaches the conquest of such endemic diseases as malaria and sleeping sickness—or at least their containment—a new problem is posed by the spread of the nematoid and fluke-propagated evils, dominated by bilharzia. With this the "worm loads" grow with the expansion in number of their often unsuspecting human carriers. Individual cases are more acute and the severity of the disease grows, over 75% of Southern Rhodesia's African population, for example, being infected and many Europeans. Control has to break a man-snail-man cycle, a vicious spiral, infected water being sprayed at its edges or snail-infested points with either copper sulphate or sodium pentachlorophenate. The immediate need, it would seem, is to alert all to the danger and to create the awareness necessary if costly controls and irritating hygienes are to prove acceptable.[1]

* * *

AutoChemic 990, a paste compound which can give high-strength corrosion-resistant joints on virtually all types of aluminium and aluminium alloys, and which requires no finishing or after treatment, has been recently made available. No filler alloy is needed, it is stated, and it is merely painted on where required, a neat fillet easily cleaned in warm water being produced by applying the compound and heating indirectly. A series of chain-type reactions take place terminating in metallic reduction at the reaction temperature of 400° C.

* * *

One estimate of the total of salts dissolved in the sea is 50,000 million tons. Despite the low bromine concentration sea-water is a major commercial source of the element

[1] *Science News Letter*, Oct. 8, 1960.

[1] *Horizon*, Dec., 1959.

formerly obtained by brine evaporation. Nowadays what is known as the Dow process dominates the industry, 15,000 tons being produced each year from about 90,000 million gal. of sea-water. In this process filtered sea-water is pumped to the top of a " blowing-out " tower after dosing *en route* with chlorine and sulphuric acid to release the bromine. Treated water trickles down over wooden grids and rising air carries the bromine up, " tailings " returning to the sea. Bromine-laden air is then mixed with sulphur dioxide and sent to an absorption tower where fresh water extracts hydrobromic acid from the reaction products. This solution is steamed out in another tower in the presence of chlorine and the resulting bromine vapour is condensed as a 99·7% pure liquid. The cleaning up of the initial impure bromine requires repeated changes from liquid to vapour. The warmer the sea-water used the better and cheaper the production, so that a relatively warm climate and a tidal current are important.

* * *

A remarkable new plastic is about to come on the European market under the trade name " Propathene "—chemically, polypropylene. This, similar to its forerunner polythene, is stiffer, stronger, and can stand up to higher temperatures. A first British plant, designed for rapid expansion, is set to produce 10,000 tons annually. Propathene may replace metals at some points, particularly in household appliances, outside guttering, etc. All this stems from discoveries by Ziegler, of Germany, and Natta, of Italy. Using catalysts containing special combinations of aluminium and titanium, which function as " growing points ", hitherto useless linkages of propylene can now grow into long chain-like molecules or " living polymers," in the way that natural hair, wool, and rubber grow. The same effect is being developed for isoprene to give an artificial rubber identical with that produced from latex.

* * *

A year of two ago it was suggested that if sufficient vermiculite were " sown " in the Sahara (about nine tons to the acre was one estimate !) and then fed with water until a primitive grass culture grew, complete desert areas could eventually be induced, virtually naturally, to become arable land. It is interesting to note, therefore, that this mineral is now to be used in Kuwait for an important hydroponic experiment and even predicted that quantities of vermiculite will also be ploughed into the top soil there in an even bolder experiment to make the arid desert hold sufficient water to grow crops. For the experiments the Kuwait Vermiculite Company has built a full-scale hydroponic installation consisting of 16 tanks each 200 ft. long by 2 ft. to 3 ft. wide, constructed of concrete and fed with nutrient solution through a port. Surplus solution is drained off into a reservoir for use again. At first full-scale trials are being carried out with a wide variety of vegetables and fruits—especially cucumbers—in order to determine the method of growing most suited to conditions in Kuwait.

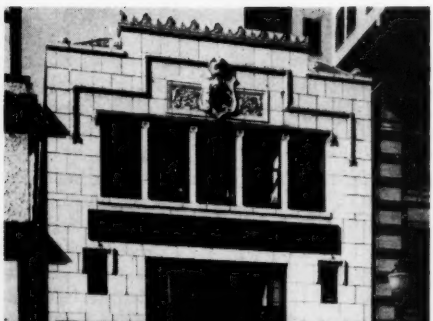
News Letters

BRITISH COLUMBIA

December 12.

Mining Regulations.—The British Columbia and Yukon Chamber of Mines has appointed a special committee to study proposed " Canada Mining Regulations " and to prepare a brief to be presented to the Federal Government. Several meetings have already been held and there is obvious concern as to proposed regulations being considered by the Department of Northern Affairs and National Resources. There is, for example, opposition to any granting of concessions in the North-west Territories, on the grounds such action would discourage prospecting, and very serious concern over the so-called " Canadian Participation Clause," which would limit mineral production to companies with at least 50% of stock held by Canadians. It is felt this clause could have a very deleterious effect on the investment of foreign capital at a time when the mining industry sorely requires such assistance. It has been pointed out that possibly half of the current exploration in western Canada is financed by United States, British, and some foreign companies and that it is inadvisable at this time, when Canadian risk money is scarce, to frighten off foreign " high-risk " capital in the search for new mines.

The matter was brought to a head at a monthly luncheon-meeting of the Vancouver Branch of the Canadian Institute of Mining and Metallurgy, when Mr. James A. Williams, director of the Division of Mines and Minerals for the State of Alaska, was the guest speaker. Mr. Williams patiently outlined proposed regulations being considered for the new State and sought the advice of Canadian prospectors and exploration groups in the formulation of policy. It was intended, he said, to extend to all aliens



Chamber of Mines Headquarters, Vancouver.

reciprocal prospecting and exploratory privileges, particularly so with regard to Canada.

Vancouver Island.—International Iron Mines has announced the successful conclusion of negotiations for a contract to sell 3,000,000 tons of iron concentrate to Japanese smelters for delivery during the five years commencing 1962 at not less than 500,000 tons annually. The ore is to be mined and beneficiated at Zeballos from the Ford property, held under lease-royalty basis from Anyox Metals, Ltd., a subsidiary of Ventures, Ltd. The company has been preparing for production for the past six months but encountered unforeseen difficulty in building a 3½-mile road to connect the existing wharf with the open-pit mine site at elevation 2,800 ft. The road is now constructed and preparation of the pit is proceeding as well as the building of the 3,200-ton mill which will produce 2,500 tons of 62% iron concentrate daily.

Recently announcement was made as to plans for equipping the Vancouver Island copper property of Coast Copper Co., Ltd., for production at the rate of 750 tons per day. In early December Mitsubishi Shoji Kaisha, Ltd., stated it had been successful in negotiating a purchase agreement with the Consolidated Mining and Smelting Co. of Canada, Ltd., for five years' production of copper-gold concentrate from its subsidiary. Shipments are to commence in 1962.

Early in November Giant Nickel Mines loaded its seventh shipment of nickel-copper concentrate since commencement in May of this year for consignment to Japan. The shipment contained 1,896 short dry tons assaying 10·1% nickel and 4·11% copper with an invoiced value of $216,807.

Lillooet.—After studies extending over the past six months Bralorne Pioneer Mines has commenced a three-stage programme to convert the Bralorne flotation mill to cyanidation, at the same time completely renewing the crushing and grinding facilities. It is expected to produce a higher gold recovery at lower cost and with greater capacity than at present. The new product will be entirely in bullion and the company will accordingly be enabled to sell in the highest market.

During the third quarter the Mel ventilation shaft from surface to the 26 level was fully equipped, the central-heating plant was converted from the use of wood fuel to an automatic oil system, and considerable progress was made in mine preparation and in the installation of a mill-tailing back-fill system. Gold production was about 30% above that for the comparable quarter of 1959 despite curtailment of Pioneer output in mid-August. The total output was 38,343 oz. of gold, valued at $1,331,905 ($35 per oz.) from 47,976 tons of ore, assaying 0·80 oz. in gold per ton. The Bralorne division supplied 32,018 oz., valued at $1,120,630, from 38,936 tons averaging 0·82 oz., and the Pioneer division 6,325 oz. valued at $221,375 from 9,040 tons averaging 0·70 oz. per ton.

The extensive mine-exploration programme was continued in both mines with emphasis on exploratory drilling. The 451B and the 2932 drives are being advanced, the first at Bralorne and the latter at Pioneer. Results are similar in each—some significant assays in narrow and irregular veins.

Beaverdell.—Sheritt-Lee Mines is continuing its cross-cut to the shear zone in the Bounty fraction adjoining the Highland-Bell mine. A recent shipment of 11·8 tons of development ore was made to the Trail smelter and assayed 0·019 oz. in gold and 103·5 oz. in silver per ton together with 4·6% lead and 9·6% zinc. The company's consulting engineer, Mr. F. J. Hemsworth, has recommended the investigation of 1,200 ft. of potentially favourable ground by extension of the 4172 East drive from the Bounty fraction into the Bounty claim. This entry is 250 ft. vertically below any existing development. Underground efficiency has been improved through the recent purchase of two 600-c.f.m. portable diesel-driven compressors, a mucking machine, and several new mine cars. A new ore-bin has been built at the lowest portal, a new road constructed to the bin, and separate waste and mill-feed dumps prepared.

Nicola.—At an extraordinary meeting of Craigmont Mines to be held on December 21, shareholders are to be asked to approve of a plan to finance production at the mine at Merritt by the early autumn of 1961. All machinery and equipment is new and a minimum of 15 years' operation has been considered from estimated ore reserves exceeding 22,000,000 tons with grade of 2·08% copper and 19·6% iron. The project represents the first big mine to reach production planning in British Columbia in several decades and has given great impetus to a "boom" situation in the mining industry on the Pacific Coast.

Yukon.—Ketzakey Silver Mines plans to work its 44-claim property, 26 miles south of Ross River, throughout the winter and to stockpile high-grade silver-lead ore at a base camp for subsequent delivery to smelter *via* the Canol Road. Four bulldozers are currently at work in the surface-extraction operation. Consulting geologists have described the main exposure as consisting of massive high-grade lead-silver ore.

EASTERN CANADA

December 21.

Ontario Gold Output.—In October the 31 producing gold mines in Ontario milled 805,753 tons of ore and produced 228,914 oz. of gold and 33,808 oz. of silver, valued at $7,860,787.

Gold production in the Province continues to rise, the output for the first eight months of 1960 totalling 1,770,777 oz., against 1,745,206 oz. in the comparative period of 1959.

Kirkland Lake.—Macassa Mines is to deepen its No. 2 winze to 6,200 ft. In the first eight months of the current year the output was valued at $1,604,705.

Quebec.—It is announced that the Anglo American Molybdenite Mining Corporation is sinking a 400-ft. shaft on its 4,200-acre property some five miles north of Cadillac. Drilling has indicated a molybdenite bismuth ore-body of some size, reserves at the end of May last being 560,000 tons of ore averaging 0·4% molybdenite.

A 200 ton a day pilot plant is to be erected by Columbian Mining Products, Ltd., at its property at Oka. The company has reached agreements with W. R. Grace and Co., of New York, and Metallgesellschaft A.G., involving marketing the production of the plant and a mutual effort to establish the product as a source of raw material. Yearly output will be 700 to 800 tons of concentrate containing approximately 450 lb. of columbium pentoxide.

In the nine months to September 30 last the Quemont Mining Corporation milled 645,078 tons of ore for an operating profit of $1,587,000. In the same period the Normetal Mining Corporation crushed 278,469 tons of ore for an estimated net profit of $1,126,000. At the last-named company's mine, it is stated, a development programme was launched in October, the first stage being a major maintenance and repair job on the timbering and cribbing of the upper part of No. 4 (internal) shaft. This work was to take about 30 days and upon completion it is planned to deepen No. 4 shaft by 600 ft. (which will take it to a total depth of approximately 6,825 ft.) and then to open up three new levels.

AUSTRALIA

December 20.

Iron Ore Export.—The Commonwealth Government has decided to lift the ban on the export of iron ore imposed in 1938 in view of the great increase in the tonnage of reserves shown by recent surveys of the iron deposits in Australia and the important increase in revenue that would accrue. The estimated tonnage of iron ore available is now put at 368,000,000 tons of proved and potential ore. Australian steel requirements are now 4,000,000 tons per year, but the demand is growing. It is understood that ore of high grade in the proved ore deposits will be strictly barred from export while limitations on quantities and periods in which shipments could be made are also to be imposed. Such limitations will take into consideration the need for those embarking on mining and export. In general there will be an overall limit of not more than 50% of the proved ore in any one deposit and of 1,000,000 tons per year from any deposit. Western Australia will benefit most from the lifting of the embargo, as it contains a number of small iron-ore deposits approximating the 1,000,000 ton figure export from which could materially benefit the State revenue.

New Zealand.—Work is proceeding on the erection of a steel mill at Otahuhu in New Zealand for the processing of scrap steel. The mill will be operated by Pacific Steel, Ltd. Output in the first year is expected to be 50,000 tons of merchant steel and production to be commenced in 1962.

Natural Gas.—Location of gas in apparently substantial quanity at Roma is increasing interest in its importance to the country. A recent report states that unless substantial sources of natural gas were found in Australia liquefied petroleum gas would have to be imported to cope with the demand. Australian refineries produced 7,360,000 gal. of liquefied petroleum gas in the year ended June 30. Consumption in the past year was 74% greater than in the previous year. Outmoded coal-gas plants in country centres are being replaced with liquid-gas systems and in Sydney and Melbourne the gas is being used to enrich coal-gas supplies.

Oil.—There is a hopeful view about the chances for discovery of oil in the south-east of South Australia following geophysical work. This basin extends into Victoria and in the western part of that State drilling is in progress at Port Campbell, in which locality a strong flow of gas was met in the first bore put down. A second bore is now in progress. On the South Australian side seismic surveys have given important information in the Beachport and Penola districts, where a deep sedimentary section has been located, while in the Mount Gambier district a series of anticlines has been disclosed. The apathy of Australian investors has been criticized in view of the growing evidence that oil discovery is close at hand.

There is a fresh report of gas in drilling at Roma where further discoveries of importance will delineate a gasfield that, it is hoped, will warrant the laying of a pipeline to Brisbane.

In Western Australia West Australian Petroleum is to continue its explorations actively while the Australasian Petroleum Co. Pty., Ltd., is drilling at Iehi, in Papua, and the hole has passed 8,000 ft. There have been showings of oil and there is considerable interest in the tests which are about to be made. So far the search for oil in Australia has cost £A56,000,000, to which Australia has contributed £A17,000,000. It has now been decided to resume work at Exmouth Gulf, the scene of the first discovery, and also in the Perth Basin, further south. The decision has been made following a conference in the U.S.A. with the company's associated. Selected areas are to be re-examined and a seismographic team will soon return to the Exmouth Gulf region.

In New Zealand American oil interests are stated to be preparing for a large-scale search in the centre of the North Island and the Government has granted licences over an area of 1,872 sq. miles.

Tin.—The State Government of Western Australia has joined with the tin-producing states of New South Wales, Queensland, and Tasmania in representations to the Commonwealth Government to obtain total exemption of taxation for tin

producers. It has been pointed out by the Minister for Mines in Western Australia, as well as by the producers in the Eastern States, that tin production has steadily declined since World War II and importation has been necessary to cope with consumption. Freedom from tax is regarded as the most suitable way to assist the producers. However, the high loss accompanying the concentration of cassiterite is still the great problem in milling. Subsidized prospecting could also be a very valuable aid to the industry, but to the producing company exemption from company taxation, freedom of dividends from income tax, and the allowance in full of calls paid to companies for income tax purposes would be of material assistance.

North Kalgurli (1912).—This gold-mining company's latest estimate of ore reserves is 2,299,378 long tons with an average grade of 5·39 dwt. per ton. Bad ground in two of the largest stopes caused difficulty in working earlier this year and grade had to be lowered ; since then, however, normal ore has been mined. A high-grade cross lode and subsidiary ore lenses have been developed at Nos. 21 and 22 levels, in the calc schist, the deepest horizons on which development is in progress. Negotiations are in progress between the company and the Kalgoorlie Electric Power Corporation, the issue being whether the company, with others, will contribute to the capital cost of modernizing the plant of the Power Corporation or whether the company will install its own electric power station.

Uranium.—The outlook for uranium is depressed, but producing companies are maintaining normal output to supply commitments under contracts which will remain in force for several years. The Australian Atomic Energy Commission has reported that Australian producers will face a period of increasing difficulty and extremely competitive conditions until the 1970's.

In the Northern Territory the South Alligator mine has met high-grade ore in development work from Sterrits No. 2 shaft. The treatment plant has closed down for the present and operations are concentrated on underground development and exploration. Rum Jungle is also reported to have located a new orebody suitable for open-cut mining.

Aluminium.—The prospect of the establishment of an aluminium smelter in the Dominion, obtaining its ore from the great Weipa deposit in North Queensland, is encouraging the search for ore deposits in New Zealand itself. Two geologists from Consolidated Zinc Corporation are to visit the country to examine bauxite deposits in Northland. The country near Takau Bay between Whangaroa and the Bay of Islands is regarded as favourable for bauxite occurrences.

Pyrite.—The question of a Government subsidy to assist in furthering the use of pyrite and pyritic concentrates for the manufacture of sulphuric acid, as against imported sulphur, has caused much anxiety amongst producers of sulphide ores and the acid manufacturers themselves. The matter of a bounty has been under consideration by the Tariff Board for some time and the decision to pay a bounty on pyrite recently announced as a result of the Board's recommendation will be of great importance.

Copper.—A Japanese company, the Mitsui Mining and Smelting Co., is taking a 20% interest in the Ravensthorpe copper mine and will subscribe for 400,000 shares of 10s. each, issued at 8s. each with an outstanding liability of 2s. per share.

FAR EAST

December 15.

Malayan Tin Industry.—When Mr. Tan Siew Sin, Federation of Malaya Finance Minister, presented his Budget recently in Kuala Lumpur he said he proposed to introduce " prosperity taxes " for rubber and tin. He said the higher tin export duty would come into effect when the tin price was $388·50 a picul, the increase working out at 5% more at $400 a picul and above. It was his firm belief that the Government must, in view of its future commitments, ensure that when the prices of the two commodities were high it should be able to use more of the proceeds for its own purposes.

Mr. D. R. Mitchell, chairman of the F.M.S. Chamber of Mines, has said that Malaya's proposed " prosperity tax " on tin—when its price gets high—is " obviously unwelcome," according to a report from Kuala Lumpur. He drew attention to the fact that the industry was trying to maintain production capacity " in spite of being forced to work low-grade ground."

It has been stated that tin-plate authorities in Pittsburgh were impressed when a Malayan delegation urged that the U.S.A. should join the International Tin Agreement. Inche Sujak bin Rahiman, economic adviser to the Malayan goodwill mission, which returned to Malaya recently, said in Kuala Lumpur that the delegation had stressed that the benevolent attitude adopted by the U.S.A. towards the International Tin Agreement was " not enough ; " it " should give active support as well." He said that if the U.S.A. joined the agreement other important tin consumers like Japan and West Germany might also join.

Borneo.—An Indonesian official is quoted as saying that a party of 21 Russians and 10 Indonesians have completed investigations of iron ore, coal, lime, and quartz deposits in East Borneo, where the Government plans to set up a steel industry. From Borneo the team was going to the Rhio islands to examine bauxite finds and then to north Sumatra, where it is intended to generate hydro-electric power. Coal mines in west Sumatra were also to be visited.

Pakistan.—An agreement has been signed between Pakistan and the United Nations Special Fund for a survey to determine the economic possibilities of exploiting iron ore and coal deposits in selected areas of Pakistan. The survey, to be completed in three years' time, will be conducted in Chichalli for iron-ore deposits and in Bogra and the Sor Range for coal deposits.

Philippines.—A mission sent to the Philippines by the Federation of West German Industries has reported that a survey of the Philippines' mineral resources " is essential." Industries there were not competitive because imports of raw materials and semi-manufactures were too expensive. Only if the basic industries were furthered could the others prosper, the report added.

SOUTHERN AFRICA

December 24.

Union Affairs.—Through the Prime Minister, the Government has stated that direct control measures will not be applied to halt the outflow of capital from the Union. Instead steps will be taken to stimulate domestic production and consumption,

investment, the export trade, and to attract new permanent overseas investment in the country. To end the present under-utilization of productive capacity and to achieve maximum development of resources, the following measures are envisaged: Expansion of the domestic market; planned expansion of productive capacity of public enterprise and of Government Departments; an appropriate taxation and budgetary policy in general; a reversal of the capital outflow, and promotion of greater exports. The Government regards as essential an acceleration of development for the implementation of Government policy to increase the standard of living of the lower income groups as rapidly as possible.

The South African Reserve Bank summarizes the trend in the third quarter of 1960 as follows: While the gold and exchange reserves continued to decline in the period, due to the adverse balance on capital account, the domestic economy expanded further but at a relatively slow rate. The gross national product which had decreased less than seasonally in the first quarter and increased more than seasonally in the second again declined less than seasonally in the third period. On balance a gradual upward movement was seemingly evident over the first nine months of 1960.

Depending on the condition of and outlook for the country's exchange position the Government has stated that it would dispense with import control as soon as possible. However, in view of the immediate outlook, a measure of caution was called for in respect of the allocation of import permits for 1961. While no basic change is contemplated in existing policy preliminary allocations for 1961 reflect general reductions, the largest being evident in those categories where supplies are more or less freely available from domestic sources of production. Where supplies are not freely available from domestic sources of production requirements will be satisfied under consideration of their domestic availability.

Business.—The British South Africa Co., De Beers Consolidated Mines, the Anglo American Corporation, Rand American Investments (Pty.), Ltd. (with which Mr. C. W. Engelhard is associated), and Johannesburg Consolidated have combined with the Rand Selection Corporation in arrangements whereby the net assets of Rand Selection will be raised to over £100,000,000, based on present market prices; its scope will be widened and it will be equipped to participate more prominently in mining and industrial development in Southern Africa. These arrangements are to be implemented early in 1961. The interests which are associated with Rand American Investments include Engelhard Industries Inc., the International Nickel Co. of Canada, the Central Mining and Investment Corporation, and Union Corporation.

It is understood that the Engelhard interests are negotiating with Kennecott Copper Corporation for the purchase from the latter of its investments in South African gold-mining companies. The negotiations were believed to be still proceeding at the time of writing.

Scaw Metals, Ltd., which has for long been closely associated with the mining industry as a supplier of cast and rolled iron and steel products, reports that demand for its grinding media has been maintained. However, it comments that an effective boycott of South African supplies has resulted in a substantial loss of export tonnages of grinding media. Recently, the company, in association with Tow Bros. Iron Works, Ltd., formed Scaw-Tow Foundries, Ltd., on the Northern Rhodesian Copperbelt. The works acquired are being modernized and extended, the programme including the installation of an electric melting shop for producing grinding media.

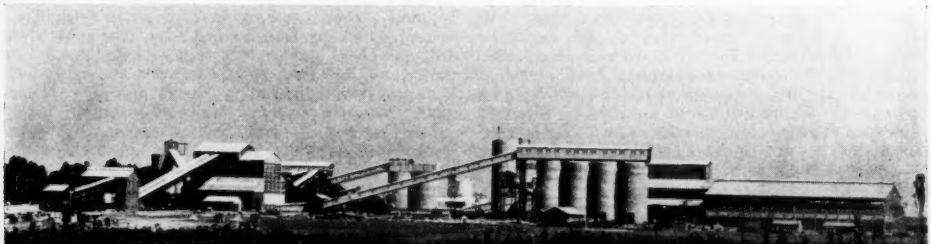
Following protracted negotiations South African Torbanite Mining and Refining has concluded agreements with the major oil-importing companies in the country to process imported oil at its Boksburg refinery to its full capacity for an initial period of 15 years. The implementation of the agreement will involve considerable capital expenditure on modifications to and replacement of plant not in excess of the company's resources. The arrangements envisaged have ensured that the Boksburg refinery will not fall into disuse, even though profits may not be increased and may even decline. A capital re-organization and bonus issue is proposed. (One of the major oil and petrol importers has already installed its refinery in the country; two others are now projected.)

Transvaal.—Hartebeestfontein Gold Mining foresees the need of a fifth main shaft system to serve the north-western section of the mine. Sinking such a system will be commenced in 1965. This section adjoins the eastern section of the neighbouring Zandpan mine and the shaft will doubtless facilitate exploratory development into the eastern section of Zandpan. Within the Hartebeestfontein mine itself the narrow reef width and extensive faulting necessitates a high broken tonnage in the mine and a high sorting rate on surface. In present circumstances and probably until the No. 4 shaft in the south-western section is commissioned, the milling rate will not be raised above 130,000 tons a month.

Venterspost Gold Mining has largely finished its programme of shaft-sinking to open up the deeper levels of the central and southern sections of the mine. In the central section the tertiary incline shaft, which has been completed and equipped to the initially projected level in the first stage, is to be deepened further to facilitate development on two deeper levels. Should disclosures there prove encouraging it will eventually be deepened further in the third stage to serve operations on two further levels.

Msauli Asbestos Mining and Exploration Co., Ltd., which in the third quarter stepped up production of fibre to 3,339 short tons from 3,197 short tons in the second period and raised estimated profits to £85,953 from £63,425, has indicated that it will continue quarrying methods of mining for as long as is economically possible and even extend its use of these methods. To this end three mechanical shovels and ancillary large tippers have been commissioned to accelerate stripping of overburden and waste.

It is understood that the company negotiating with Rand Collieries and Fuel, Ltd., for an option contract over its mineral rights other than coal is Johannesburg Consolidated. These mineral rights extend over about 1,429 claims in what is believed to be an unbroken block. This constitutes about 22% of what would be considered a reasonable lease area for the Kinross sector of the Eastern Transvaal. It is understood that negotiations are still proceeding, mainly on the point of what would constitute an equitable participation for the Rand Collieries company in any future mining company which may be formed to exploit the area.



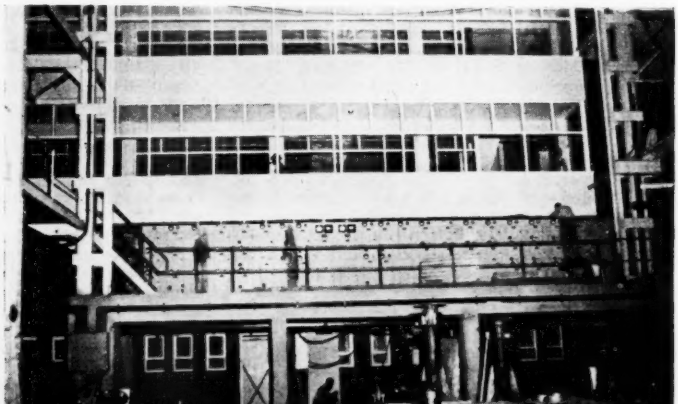
New Gold Plant at East Rand Proprietary.

The Free State Development and Investment Corporation is extending its drilling operations immediately east of the ground held by Western Holdings, Ltd., on the southern bank of the Vaal River, south of the Vaal Reefs and Buffelsfontein mines. The recently-completed bore-hole on the eastern boundary of the Free State Development ground passed into foot-wall measures at 8,003 ft., the Vaal Reef being faulted out.

Following assumption of control by Johannesburg Consolidated Investment, African Asbestos-Cement Corporation, Ltd., arranged to obtain electric power supplies from the Electricity Supply Commission by about June, 1961. Pending this a temporary power station has been installed and additional compressed-air capacity provided. This has facilitated expansion of mining operations. A three-year capital expenditure programme aims at further improving the mine's facilities. The grading plant is being modified and expanded to give production grades demanding higher forward contract prices.

Orange Free State.—The South African Coal, Oil and Gas Corporation, Ltd., in the Northern Free State south of Vereeniging, in 1959–60 produced 35,000,000 gal. of petrol and sold nearly £2,880,000 of chemical by-products. Extensions are now under way, at a cost of £3,500,000, which, scheduled for completion by about mid-1961, will raise petrol-producing capacity to 40,000,000 gal. a year. This will complete the consolidation programme, but plans have now been formulated to implement a further programme of expansion, scheduled for completion within about 7 to 8 years. This will have the objective of practically doubling the output capacity of the plant in petrol and chemical by-products at a cost of about £30,000,000.

Cape Province.—The new mine of South African Manganese in the Kuruman area of the Northern Cape has been developed to the point where production at the planned rate of 240,000 tons of manganese ore a year can be anticipated in the very near future. Development of the new mine was retarded by



Control Panel and Offices in the E.R.P.M. Mill.

unexpected areas of ferruginization in the manganese ore-body and had, therefore, to be extended beyond the planned footage. In the Lohathla area workings the output of higher-grade ores is presenting increasing difficulties and deficiencies therein are to be made good by drawing tonnages from the new mine, where an expansion of output capacity beyond the planned rate is envisaged. The extension of the rail-line from Sishen to the area of the new mine will be completed in the early part of next year and electric power will become available from the network of the Commission at the southern workings late next year and at the new mine towards the end of 1962.

The new ore-loading installations and berths being prepared at Port Elizabeth by the Railways Administration have encountered unexpected delays and completion and commissioning are now not anticipated much before 1963.

The current programme of expansion by the South African Iron and Steel Industrial Corporation, Ltd., is expected to be completed next autumn at a cost of about £56,000,000, when the estimated output capacity will be about 2,350,000 tons of ingot steel. Output in 1959–60 was 1,748,527 ingot tons. By 1964–65 estimates indicate that a further 500,000 ingot tons will be required annually. By 1972 domestic requirements of the Corporation's production is expected to reach 4,350,000 to 4,500,000 ingot tons. The Corporation has therefore decided to embark on a further programme of expansion over a period of 12 years at a cost of some £270,000,000 to £280,000,000. This will involve a considerable expansion of output at the Thabazimbi iron-ore mines.

Swaziland Protectorate.—Agreement has been reached between a Japanese consortium on the one hand and Anglo American Corporation of South Africa and its associate—Swaziland Iron Ore Development Co., Ltd.—for the purchase from the latter of 1,200,000 tons of iron ore a year over 10 years, commencing from 1964. The project includes the construction of a rail-link to facilitate shipment through the port of Lourenco Marques. The agreement is provisional on the findings of a mission from the consortium in a survey of the deposits being conducted. All the participants in the consortium are not known, but major members are the Yawata Iron and Steel and the Fuji Iron and Steel, and the Nittetsu Mining, Mitsui Bushan, and Kinoshita companies. The last two companies are understood to have acquired a 20% interest in the Swaziland company mentioned. The price contracted for is 70s. a ton.

Trade Notes

Brief descriptions of developments of interest to the mining engineer

Prospecting by Electromagnetic Inductive Methods

Particulars have been made available of portable and self-contained ground electromagnetic prospecting equipment by the **ABEM Company** (AB Elektrisk Malmletning), of Stockholm, and called the E.M. Gun. This is a lightweight portable, two-man operated, equipment for reconnaissance and detailed surveys in ore prospecting by the inductive method, making use of the fact that electrical conductors, when subjected to a primary alternating electromagnetic field, create secondary fields, the phase and amplitude of which differ from those of the primary applied field. By detecting and measuring the differences the presence and location of conductors may be established even when these are buried at some depth under the surface. In E.M. Gun surveys the primary field is set up by a transmitter unit comprising a transistorized oscillator and a transmitter coil wound on a ferrite core (the transmitter staff). Measurements are made with a receiver unit comprising a compensator-amplifier and a receiver staff (see illustration).

The E.M. Gun may be used both for pin-pointing anomalies detected by airborne electromagnetic surveys and for obtaining detailed information about the conductors so located. Measurements are usually carried out with the transmitter and the receiver staffs connected by a lightweight reinforced feeding cable and kept at a certain selected distance apart. The two men move from observation point to observation point using the feeding cable as a measuring tape and at each point take readings of the in-phase and out-of-phase horizontal or vertical field components

ABEM Co.
E.M. Gun.

acting on the receiver staff; these readings may be taken at a high and a low frequency. In addition the Gun may be used to obtain measurements of the inclination of the electromagnetic field at the receiver; these measurements may also be obtained without a cable connexion between the transmitter and receiver staffs, thus giving greater flexibility during fast reconnaissance surveying.

Comminution Instruction Film

Size reduction by breaking, grinding, or crushing is the subject of a new film produced by International Combustion, Ltd. In colour, it has the instructional approach to promote an understanding and appreciation of a field of engineering playing a vital part in many industries. A film of this type, in establishing a basic knowledge of the subject of comminution by visual presentation, is admirably suited for instructional use in the training of students or technologists. It shows the pattern of historical development, theoretical approach, research, testing and application, animation being freely used throughout. International Combustion is intimately concerned in supplying equipment covering the broad fields of comminution in industry, their close association with the problem having shown the need for a film of this type.

Powder Metallurgy Technique for Reactor Control

A new high-temperature reactor control material called Bo-Stan is a balanced uniform dispersion of boron in stainless steel. It is prepared by the "Sinterwrought" process, an advanced powder metallurgy technique developed by the Sintercast Division of the Chromalloy Corporation in New York. As it is produced by a solid-state process the resulting material is readily predictable, reproducible, and homogeneous. After sintering and hot-working the composite is as fully dense, ductile, and strong as a cast alloy of equivalent composition.

Boron, owing to its affinity for neutrons, is of vital interest as a flux attenuator in nuclear reactors. Theoretically its combination with stainless steel offers an ideal material which is strong, easily fabricated, and resistant to corrosion and high temperatures. This combination is of particular interest in pressurized water reactors where problems of oxidation and high temperature prohibit the use of aluminium and its alloys.

Despite many recent advances—such as, the use of vacuum fusion—alloys of boron and stainless steel suffer serious disadvantages. One major difficulty lies in the tendency of boron literally to ooze out of the alloy, especially during hot-working. This deboronization drastically alters the neutron-capturing ability of the reactor material,

sometimes very unevenly. In nuclear technology uniformity of boron distribution in the stainless-steel carrier metal is of particular importance. With conventional alloying procedures employed to date boron could not be dispersed uniformly. Because the lighter element segregated more boron accumulated in some areas than in others. Such a condition is intolerable in a material used to control neutron flux.

These disadvantages are stated to have been minimized by the Sinterwrought process, which permits more precise control of composition and greatly reduces the problem of deboronization. Moreover, the special blending techniques employed have all but eliminated the tendency of boron to segregate. Once a homogeneous mixture has been obtained uniformity of the dispersion is undisturbed by subsequent sintering and hot-working.

In contrast with conventional melting and casting powder metallurgy permits selection of optimum particle size and spacing of the neutron-absorbing constituent. Because capture of free neutrons depends on the spacing of boron nuclei, control over micro-structure allows more precise regulation of the pile. The solid-state production method has still a further advantage—purity of product. Because constituents are never molten there can be no absorption of foreign matter from addition agents, the atmosphere, or mould materials so that contamination is thus reduced to a minimum.

Bo-Stan consists of boron or compounds such as boron carbide uniformly dispersed in a matrix of stainless steel, usually with low carbon content—such as, type 304L. At present up to 2% boron can be incorporated; larger boron contents are soon expected to be feasible.

In processing powdered constituents are first weighed out corresponding to the final composition desired. After that special mills achieve homogeneity and the mixture is then pressed into "green" compacts or billets. During sintering, which takes place at a temperature below the melting point of any constituent, the metal particles bond into a solid but porous composite. It is believed that at this stage the boron may actually alloy with the iron through diffusion. To eliminate all porosity compacts are hot-worked. When fully densified the composite is almost undistinguishable from its vacuum-melted and cast counterpart in its physical properties. However, analysis of the micro-structure reveals that Bo-Stan, unlike the cast alloy, is completely homogeneous; it has suffered little if any loss of boron. Sintercast is currently developing improved methods of analysing the boron content and uniformity of dispersion. Final fabrication is performed by cold-rolling, sizing, or machining and almost any shape can be furnished to meet customer specifications.

Other products of the Sinterwrought process include Binal, a highly ductile boron-aluminium composite, ideal for lower-temperature nuclear uses, and a unique series of rare-earth composites. Such unusual elements as dysprosium, gadolinium, samarium, europium, or holmium dispersed in either aluminium or stainless steel offer the nuclear designer an entirely new family of reactor materials with intriguing possibilities.

Personal

A. F. ALEXANDER has resigned from his appointment with the National Coal Board and is now a lecturer in the College of Building, Liverpool.

ROBERT ANNAN, a director of Consolidated Gold Fields of South Africa, Ltd., since 1935 and chairman since 1944, retired at December 31 last. He has been appointed president of the company and will be available for advice and consultation. As chairman he is succeeded by *Sir* GEORGE HARVIE-WATT, deputy chairman since 1954.

L. F. CAMPBELL-PITT has been appointed an executive director of Gold Fields of South Africa, following 26 years of service with the group in various capacities, 13 in the position of group consulting mechanical and electrical engineer. He has been succeeded as group consultant by F. G. ZEPPENFELD.

J. C. COLQUHOUN has retired as chairman of the Manganese Bronze and Brass Co., Ltd.; he is succeeded by J. C. BUDD.

ARTHUR C. DAMAN, Jr., has recently returned to Denver from Lima, Peru, and is now attached to the International Sales Division of the Denver Equipment Company, headquartered in Denver.

CHARLES W. ENGELHARD has been elected a director of the Anglo American Corporation of South Africa, Ltd.

I. C. A. GORDON has left for Ghana.

R. N. HARLE has been appointed consulting mining engineer to the Rhodesian Selection Trust group in succession to J. P. NORRIE, who has retired.

JOHN H. HOHNER has been appointed managing director of the Rio Tinto Mining Co. of Australia, Pty., Ltd.

W. HUME-ROTHERY, Isaac Wolfson Professor of Metallurgy in the University of Oxford, has been elected an Honorary Member of the Institute of Metals.

H. SOMMERFELDT JACOBSEN has been appointed managing director of Svenska Diamantberg Borrnings A.B. in Stockholm, with Mr. SVEN PETERSSON and Mr. G. NORLING as his deputies.

R. R. KENNAN has joined the board of Ferry-Diamond Engineering Co., Ltd., of Southampton. He will still retain his directorships of Mono Pumps

Africa (Pty.), Ltd., and Mono Pumps (Australia) Pty., Ltd., and remain general sales manager of Mono Pumps, Ltd.

M. N. PERRINS, home from Malaya, is now in the Isle of Man.

GERT PRALLE has left for the United States.

I. A. TAYLOR has been appointed technical and labour adviser to the Chamber of Mines of Rhodesia.

FRANCIS ROBERT PETERS, who died on December 16, aged 74, joined the British South Africa Police in 1906 and in 1911 was selected for the Coronation Contingent for the Coronation of King George V. After leaving the police he entered into business as a mining contractor in Southern Rhodesia and in 1920 returned to London. At the time of his death he was the chairman of the Rhodesian Corporation, Ltd., and the Oceana Development Co., Ltd., as well as a director of the Bremang Gold Dredging Co., Ltd.

RIDGEWAY ROBINSON WILSON, a leader in the mining development of British Columbia, died in retirement at Santa Barbara, California, on November 19 at the age of 69. He was born in Carnegie, Pennsylvania, and graduated from Queen's University, Kingston, Ontario, in 1913 as a bachelor of mining and metallurgy. Like his father, the late W. R. WILSON, a former president of the Canadian Institute of Mining and Metallurgy, the younger Wilson made a reputation in the early history of the fabulous Premier gold mine and later as the founder of the very successful Silver Standard Mines, Ltd.

GEORGE HAMNALL BOSWELL, formerly Professor of Geology in the Imperial College, died on December 22, aged 74. A demonstrator and research student at the Royal School of Mines from 1913 to 1916 he was from 1916 to 1919 Scientific Adviser (Geological) to the Ministry of Munitions and British War Mission, in 1917 taking up the Herdman Chair of Geology at Liverpool. In 1930 Professor Boswell was appointed Professor at the Imperial College, retiring as Emeritus Professor in 1938. He was president of the Geological Society in the session 1940–41. While advising the Ministry of Munitions, Boswell was called upon to investigate British supplies of moulding sands for use in metal foundries and, as a result, became an authority on sedimentary petrology. He also acted as adviser for the Metropolitan Water Board for some 20 years from 1934, being concerned with the falling water table under London.

Metal Markets

Year-End Notes [1]

Copper.—The fact that copper prices ended December lower than they began it seems somehow in tune with the closing month of a year in which confidence in copper tended at all times to be a rather tender plant. December saw repeated crises in the process of building up to a strike at the El Teniente mine in Chile beginning on January 1, but at no time did these crises do more than hold up prices [1] in London in the face of an otherwise weak situation. Also during December it became fashionable to argue that, at any rate as far as the U.K. was concerned, copper consumption was still at a distinctly good rate and the various restrictions on the economy here that had been introduced could be largely discounted in their effect on copper. The statistics, always of necessity behind events, seemed to support this view, but day-to-day business evidently did not and the view lost ground, especially against the general background of oversupply.

The Christmas holiday, of course, foreshortened the working month and introduced a seasonal element into the market which is traditionally one of reduced activity, if not stagnation. This year was hardly an exception. Not only did day-to-day consumer demand shrink back, as already indicated, but offerings began to increase. One source was the U.S.A., whence material was offered both to buyers and, it was widely believed, on the London market. The situation over there, of course, was as it had been for so much of the year, distinctly dispiriting, with producers' stocks already at a high level and apparently rising higher. The turn of the year is always a time for reviewing and predicting and it must be reported that most predictions about copper in the U.S.A. are extremely cautious for at least the first quarter, if not longer.

Another turn of the year feature that was by no means recurring was the outbreak of civil disorder in Belgium. This appears to have had mixed effects on the metal industry there, with the big copper smelter apparently little affected so far.

Copper consumption in the U.K. in October was 62,372 tons, of which 47,498 tons were refined. Production of primary refined copper was 9,068 tons and of secondary refined 10,604 tons. Stocks of refined copper were a little higher at 96,469 tons and noticeably higher where blister was concerned, being 21,564 tons.

Tin.—December has again been something of a mixed month for tin. While the authorities and experts continue to predict a statistical strength, with particular reference to a projected shortfall in production against consumption both in 1960 and 1961, the market continues to eye tin with reserve and to mark lower prices quite readily. Prices [1] did not begin to drift seriously away from £800 per ton for cash

[1] Recent Prices, pp. 8, 48.

[1] See Table, p. 48.

metal until about Christmas-time, but since then they have hardly recovered at all and seem to have settled at about £790.

It is true perhaps that the most important specific development in tin in December was the decision by the International Tin Council to continue complete freedom from restraint on producers for the first quarter of 1961; however, this was felt by many people to be not so much a bearish factor as a reflection of a potentially bullish situation—namely, the statistical forecast of a shortfall in supplies. All things are possible and the U.S. tinplate industry, which has been the weak spot in the tin picture for the whole of 1960, could always get worse. The general feeling, however, is that it is not very likely to get much worse before eventually it gets better. When this will be, however, is hard to say except that it is not immediately. When it does happen, however, the alignment of market and statistical viewpoints can hardly be delayed any longer.

U.K. October consumption was 1,951 tons and production 1,903 tons, substantially down from the previous month's good showing. Stocks were negligibly lower at 11,248 tons.

Lead.—December in the lead market was again a month of too much metal and too few buyers—and depressed prices in consequence.[1] Aggravating the oversupply position which has been at the root of the market's troubles all through the year was the fear in the first part of the month of very heavy arrivals of Spanish lead such as are regularly experienced every few months. With demand already affected by the present economic difficulties—if it has not yet actually fallen from recent levels it is certainly not increasing as was the case earlier in the year—prices went from bad to worse before Christmas. Holiday influences also tended to cut new buying to a minimum as the month wore on, as did considerations of year-end stocktaking. From the middle of the month onwards, therefore, interest was about as low as it is ever likely to be unless there is a real economic slump and not just a recession. Prices closed the year only shillings above a new post-war low established on December 29.

Overshadowing the future for lead there is the uncertain economic outlook for at least the first few months of 1961 and sentiment, suffering accordingly, seems likely to continue to do so in the immediate future. It is to the United States that most people are now beginning to look for some improvement in consumption to make itself felt first. As far as the market outside the U.S.A. is concerned, and particularly the U.K. market, the registration of Russian lead on the London Metal Exchange for the first time on December 29 has done nothing to brighten the immediate prospect. As always, where Russian metal is concerned, there are underlying fears of dumping or, at best, of large quantity arrivals from the U.S.S.R. in the next few months. The fact that recent arrivals of Russian metal have been on a larger scale than hitherto has accentuated such fears. It remains to be seen how well founded they will prove to be.

United Kingdom lead consumption in October amounted to 32,680 tons. Production in the same month was 7,662 tons of English refined lead and end-October stocks were 60,218 tons, as compared with 58,157 tons at the end of September.

Zinc.—The sharp knocks taken by the zinc market in the last few weeks and the price falls recorded in December, some of which were quite spectacular, were the result of several factors the most important being a shift in the supply position to one of a surplus of nearby metal.[1] This was caused by a heavy rate of arrivals of American zinc, for which there is currently no outlet on the U.S. domestic market because of the lack of demand there—a feature of the American scene all through 1960.

As well as this American metal, which has been arriving in quantity, there was also a noticeable increase in the rate of arrivals of zinc from the U.S.S.R. in December. Other factors contributing to the depressed state of the market generally were (as with lead) the uncertainty over future consumer requirements, which is likely to remain a feature of the market until there is some clarification of the present economic outlook and the usual holiday and year-end influences which always result in a rather depressed market just before and after Christmas.

As with lead, it seems that the United States must give a lead with an improvement in the level of offtake before there can be any real and lasting improvement in the market as a whole. As things stand, although consumption in the U.K. and on the Continent is almost certainly now running somewhat below the earlier peak, it is still quite good overall and certainly good when compared with last year at this time. It seems pointless, therefore, to expect future consumption outside the U.S.A. to have very much effect on the market by itself unless it has a further adverse effect by declining too greatly.

[1] See Table, p. 48.

[1] See Table, p. 48.

October zinc consumption in the U.K. totalled 30,598 tons. Output in the same period amounted to 5,291 tons and end-October stocks stood at 49,871 tons, as compared with 52,717 tons at the end of September.

Iron and Steel.—Christmas holidays naturally affected U.K. steel production but a very high rate was maintained nevertheless, making the total for 1960 a record 24,200,000 ingot tons, as compared with 20,200,000 tons in 1959. It has thus been an active and on the whole very prosperous year for the steel industry, although the emphasis of demand shifted during the 12 months. At the beginning of the year it was the mills producing light products, in particular sheet steel, which were the busiest and the mills' heavy rolling sections and plates were still not completely out of the doldrums. As 1960 ended, however, the swing of trade had gone against sheets because of motor-trade and other consumer-goods sales difficulties, whereas the demand from capital investment industries for heavy steel had picked up enormously. Demand for strip and tinplate was also showing some easing, but re-inforcing rounds were enjoying brisk conditions.

The outlook for 1961 is to some extent obscure but by no means, it would seem, particularly gloomy. On the light-product side it is expected that activity will be a little less intense in the first quarter or even first half than in 1960; beyond, much depends on the fortunes of the motor-car industry which is now fairly depressed, although fortunately commercial vehicle production is holding up. On the heavy side mills already hold order books extending into the second quarter so a high level of production is guaranteed. The fall in tinplate export demand is, it is hoped, only seasonal, but foreign competition will be severe, as it will be in all steel products on overseas markets.

On the basis of the general trend the steel industry feels that it should be able to produce between 24,000,000 and 25,000,000 ingot tons in 1961, or a similar figure to last year's output.

Iron Ore.—With quite heavy imports in the final part of the year total arrivals of iron ore in 1960 are expected to have been close to 18,000,000 tons, an all-time record.

Aluminium.—A/S Norsk Aluminium is a member of the world-wide Alcan group. It is not surprising, therefore, to see its managing director, Mr. N. Ramm, following the lead given recently by Mr. N. V. Davis, president of Aluminium, Ltd., and warning in his year-end review of the Norwegian aluminium industry against too much expansion of output capacity without due thought to future needs. Nevertheless Mr. Ramm's remarks are of more than usual interest this time because of the amount of attention now being paid to Norway as an area for future primary production projects.

New projects currently planned in Norway represent an increase in total Norwegian output of the order of 600,000 metric tons per annum in the course of the next 10 years. If they come to fruition, as things stand at the moment, Norway will then be the world's third largest aluminium producer, surpassed only by the U.S.A. and Canada. Projects already realized or definitely approved for the near future in themselves represent an output of 240,000 metric tons.

Of course, as Mr. Ramm pointed out, present projects in Norway depend in most cases on the availability of cheap electric power and as so far only 25% of Norway's water power has been harnessed this important factor will continue to influence future planning for some considerable time to come. However, as Mr. Ramm also said, the focal question remains demand. How right he is, of course, and anyone who may not think so has only to look at the situation on the other side of the Atlantic where the lessened demand for primary metal in recent months has meant a number of closures at various plants—particularly in the United States.

Antimony.—Until the end of December, when it was announced that (effective January 1) English regulus prices were to be raised by £10 per ton to £210 for 99% and £217 10s. for 99·6% material, the antimony metal market had been fairly featureless for some weeks. Not so the antimony ore market, however, which has had a firm tone—indeed a strong tone—throughout the month. It was, in fact, the strength of the ore market which caused the increase in regulus prices, although with its special long-term supply contracts the U.K. smelter was at a considerable advantage over smelters on the Continent and elsewhere.

On the open market keen smelter buying had been sustained over a period of some weeks and showed no signs of lessening with the approach of the year-end. In consequence prices tended to be forced up. Although individual deals were done at a variety of prices, dependent on the quality and the amount of material in each parcel, as is usually the case when dealing with merchants, for 60% ore both European and Far Eastern consumers (the latter notably in Japan) paid up to 26s. c.i.f. per unit of metal contained. Other material (50% to 45%) was fetching up to 24s. per unit by the end of December.

Arsenic.—Arsenic prices were again unchanged throughout December at £400 per ton

for the metal and £40 to £55 per ton, ex store, for the trioxide.

Bismuth.—Bismuth, like arsenic, has not changed in price for many months past. In December it was again quoted at a nominal 16s. per lb. for 1-ton lots, ex warehouse.

Cobalt.—December brought no alteration in cobalt prices, which last changed in March, 1960. Open-market material was once more quoted at 12s. per lb. delivered as against 10s. 9d. per lb. for contract metal. Cobalt oxides (black and grey) were quoted at 7s. 10d. and 8s. 4d. per lb. respectively.

Cadmium.—After the increases in the British prices of U.K. and Commonwealth (and then Belgian) cadmium in November and the earlier increase in the price of U.S. metal imported into the United Kingdom (both of which were discussed in last month's report) prices held steady in December at 10s. 9d. to 11s. per lb., duty paid, for imported foreign metal and 11s. per lb. for U.K. and Empire material. Both these prices refer to 1-cwt. lots.

Chromium.—Chromium metal prices were again unchanged in December at 6s. 11d. to 7s. 4d. per lb. However, observers looking at the export pattern for the 12 months ended October 31 have noted a substantial decline in the volume of chromium metal shipments to the U.S.A. (once our major export market). This has given rise to suggestions in some quarters that a period of price competition on the home market may be on the way unless some suitable alternative overseas market is found. China is a new and growing market for U.K. chromium metal, but the outlook will certainly depend on our present rate of export to that country being expanded still further if there is not to be a heavy surplus at home—unless, of course, still further new export outlets are found and built up in the next few months.

Tantalum.—After the steady increase in tantalite prices in November the market was still firm in December. It was, however, a good deal less active than the previous month but prices held steady throughout, with ore assaying 60% Ta_2O_5 quoted at 1,000s. to 1,200s. per unit.

Platinum.—December was another quiet month for the platinum market with Commonwealth material again quoted at £30 5s. per troy oz. despite an almost complete lack of demand. Demand was similarly lacking so far as open-market material was concerned, but about midway through the month quotations were reduced to £27 10s. to £28 5s. per troy oz. against £28 5s. to £28 15s. previously. So far, at least, this does not appear to have had any effect on sales.

Iridium.—Iridium prices were again unchanged in December at £20 to £26 15s. per troy oz.

Palladium.—December was another featureless month in the palladium market with quotations again unaltered at £8 10s. to £9 7s. 6d. per troy oz.

Osmium.—In common with open-market platinum, osmium quotations underwent a little shading in December. The present range stands at £17 to £25 per troy oz.

Tellurium.—Tellurium, too, was a quiet market in December with quotations unchanged throughout the month at 28s. 6d. per lb. for lump and powder and 40s. per lb. for tellurium sticks (minimum 99%).

Tungsten.—Buying interest in tungsten ore during December was such that for the most part only very moderate tonnages changed hands and those at prices within the same range (148s. to 153s. per long ton unit c.i.f.) that ruled throughout November. Twice during the month, however (at the beginning and then just before the Christmas holiday) there were some cheap offers of Czechoslovakian ore which caused misgivings at the time among traders in this country. Their fears did not last, however, and many of them indeed were looking forward to something of a renewal of consumer interest in the New Year.

One factor that might disturb the market in the next few months, however, is the reported decision of the Korean Tungsten Mining Corporation to terminate its supply contract with the Continental ore group in mid-January. Ever since the decision was made in mid-December the trade has been speculating as to whether or not future sales of Korean ore (scheelite) are likely to be made on the old basis of monthly auctions. If so market prices might well be depressed, for the prices realized in the past by such auctions were generally anything but advantageous.

Nickel.—The main event of note as regards the nickel market in December was a review of the year issued by the chairman of International Nickel, Mr. H. S. Wingate. One of the outstanding features of the market during the year (and in marked contrast to many other metal markets) has been the continued lack of price competition, with refined nickel standing at £600 per ton throughout in all markets. Another contrasting feature is the extent to which anticipated 1960 consumption has

exceeded actual consumption in 1959. Non-Communist world nickel usage in 1960 is estimated at more than 250,000 short tons, against actual usage of only 220,000 tons the year before, and Mr. Wingate apparently sees no slow-down in the rate of consumption in 1961. If his forecast proves correct it is unlikely that there will be any raising of the current producer-maintained price. The increased sales expected will be needed to absorb the extra production which will be forthcoming this year, it is true, but unless something untoward develops it seems most likely that the present price will again hold throughout the year.

Chrome Ore.—The chrome-ore market in December was no more active than in November with deals continuing on the basis of existing supply contracts. With no new features arising in the market prices were again quoted at £15 15s. per ton c.i.f. for Rhodesian metallurgical ore and a nominal $33·50 per ton for similar grade Turkish ore.

Molybdenum.—There was no change in the molybdenite market in December and prices were quoted throughout at 8s. 11d. per lb. Mo contained f.o.b. mine for Climax material and 9s. 3½d. per lb. c.i.f. for material from other sources.

Manganese Ore.—Trading in manganese ore was of a routine nature in December although prices were indicated for the most part at 68d. to 71d. per unit against 66d. to 71d. previously. The change does not in itself, however, represent any improvement in the market. Indeed, with United Kingdom requirements for 1961 virtually filled at the beginning of December and other buyers rapidly concluding the remainder of their contracts the market is, if anything, rather worse now than in recent months for there are still plenty of sellers about.

Many observers have indicated that they expect to see Brazil feature among the United Kingdom suppliers this year as well as the more established countries like South Africa, India, and the U.S.S.R., for even before the U.S. steel industry began to experience its recession in 1960 it was planned that Brazilian output would exceed U.S. requirements. Now, however, with U.S. demand drastically curtailed, it is widely assumed that Brazilian suppliers will have been making determined efforts to sell some of their surplus to the U.K. and elsewhere in recent months.

Tin, Copper, Lead, and Zinc Prices

Date		Tin		Copper		Lead		Zinc	
		Settlement	3 Months	Spot	3 Months	Spot	3 Months	Spot	3 Months
		£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.
Dec.	9	797 10	794 15	233 12½	230 7½	65 13¾	66 18¾	86 0	85 8¾
	12	796 10	794 15	234 7½	230 17½	65 13¾	66 12½	84 12½	84 7½
	13	797 10	795 5	234 2½	230 7½	65 17½	66 17½	83 16¼	83 18¾
	14	797 10	795 15	230 12½	227 17½	65 6¼	66 12½	82 11¼	82 16¼
	15	799 0	796 5	229 7½	226 7½	64 18¾	66 6¼	81 17½	82 2½
	16	798 0	795 5	228 17½	225 17½	65 13¾	66 11¼	82 5	82 7½
	19	796 10	793 15	226 12½	224 12½	63 17½	64 18¾	80 12½	80 18¾
	20	795 0	792 5	226 2½	224 7½	63 6¼	64 7½	80 6¼	80 6¼
	21	793 0	791 5	228 7½	226 7½	64 2½	65 7½	80 11¼	80 17½
	22	793 0	790 15	230 7½	227 17½	64 6¼	65 11¼	80 17½	71 2½
	23	791 0	790 5	230 17½	228 7½	64 6¼	65 8¾	79 18¾	80 3¾
	26	—	—	—	—	—	—	—	—
	27	—	—	—	—	—	—	—	—
	28	789 10	788 15	228 7½	226 5	63 17½	64 18¾	78 2½	78 16¼
	29	787 0	785 15	227 7½	225 7½	61 17½	63 8¾	76 12½	77 2½
	30	788 0	787 15	228 2½	226 7½	62 2½	63 17½	78 6¼	79 2½
Jan.	2	—	—	—	—	—	—	—	—
	3	790 0	790 5	226 7½	225 12½	63 15	64 8¾	80 7½	78 17½
	4	788 10	788 15	224 12½	224 7½	62 17½	63 17½	80 7½	78 11¼
	5	788 10	789 5	223 12½	224 7½	63 6¼	64 6¼	80 2½	78 8¾
	6	788 10	789 15	223 12½	224 7½	64 2½	65 2½	81 5	78 18¾
	9	786 10	788 5	222 12½	223 2½	63 17½	65 1¼	80 7½	78 17½
	10	783 10	785 10	216 17½	217 12½	63 7½	64 11¼	78 8¾	76 16¼

Statistics

TRANSVAAL AND O.F.S. GOLD OUTPUTS

	November		December	
	Treated Tons	Yield Oz.†	Treated Tons	Yield Oz.*
Blyvooruitzicht	135,000	87,548	128,000	83,035
Brakpan	142,000	17,603	146,000	17,747
Buffelsfontein‡	148,000	61,054	146,000	60,225
City Deep	117,000	24,185	112,000	23,138
Cons. Main Reef	48,000	10,763	45.000	10,410
Crown Mines	184,000	33,075	175,000	30,978
Daggafontein	220,000	44,709	215,000	43,452
Dominion Reef	43,100	576	37,500	540
Doornfontein‡	105,000	43,297	105,000	43,307
D'rb'n Roodeport Deep	185,000	33,796	183,000	33,694
East Champ D'Or‡	12,500	268	12,500	347
East Daggafontein	108,000	18,362	104,500	17,908
East Geduld	125,000	36,250	120,000	34,810
East Rand P.M.	216,000	50,265	216,000	50,928
Eastern Transvaal Consol	19,700	5,978	19,300	5,852
Ellaton‡	26,000	6,191	26,000	6,193
Freddies Consol.	60,000	12,628	58,000	13,262
Free State Geduld	95,000	82,173	93,500	81,111
**Free State Saaiplaas	30,000	£67,123	40,000	£94,457
Geduld	78,000	13,166	76,000	12,761
Government G.M. Areas‡	53,000	10,275	52,000	9,893
Grootvlei Proprietary	225,000	46,578	220,000	45,534
Harmony Gold Mining	170,000	68,941	165,000	66,821
Hartebeestfontein‡	125,000	58,127	124,000	57,784
Libanon	117,000	27,999	115,000	27,889
Loraine	82,000	17,917	81,000	18,399
Luipaards Vlei‡	118,000	13,411	113,000	13,060
Marievale Consolidated	98,000	24,059	94,000	23,177
Modderfontein East	120,000	11,535	57,000	7,467
New Kleinfontein	78,000	10,288	72,000	10,100
New Klerksdorp‡	10,500	1,011	9,900	1,114
President Brand	118,500	94,503	115,000	91,427
President Steyn	108,000	40,229	105,000	39,283
Rand Leases	184,000	26,312	188,000	26,508
Randfontein‡	158,000	9,082	167,000	10,206
Rietfontein Consolid't'd.	14,000	3,400	14,000	3,369
Robinson Deep	45,000	10,253	44,000	10,004
Rose Deep	25,000	4,280	24,000	4,280
St. Helena Gold Mines	178,000	61,853	172,000	59,784
Simmer and Jack	72,000	12,731	70,000	12,720
S. African Land and Ex.	100,000	20,751	98,500	20,440
S. Roodepoort M.R.	30,000	7,172	29,000	7,183
Spaarwater Gold	11,000	3,432	10,800	3,451
Springs	95,000	12,942	92,000	12,667
Stilfontein Gold Mining‡	168,000	76,395	168,000	76,380
Sub Nigel	66,500	15,046	64,000	14,749
Transvaal G.M. Estates	5,900	1,948	—	—
Vaal Reefs‡	101,000	46,966	101,000	46,945
Van Dyk Consolidated	75,000	11,476	73,000	11,290
Venterspost Gold	122,000	34,032	114,000	32,753
Village Main Reef	28,500	4,018	30,000	4,170
Virginia O.F.S.‡	140,000	29,981	129,000	27,890
Vlakfontein	51,000	18,561	50,000	18,204
Vogelstruisbult‡	84,000	17,648	81,000	17,502
Welkom Gold Mining	99,000	31,641	96,000	30,431
West Driefontein‡	130,000	121,547	130,000	121,529
West Rand Consol.‡	206,000	20,902	201,000	20,268
Western Holdings	155,000	105,662	155,000	106,175
Western Reefs	135,000	38,813	135,000	38,814
Winkelhaak	95,000	32,200	92,000	31,301
Witwatersrand Nigel	20,000	4,435	19,400	4,301

† 253s. 10d. * 252s. 8d. ‡ Gold and Uranium.
** Oct. and Dec. wrongly shown as oz. instead of £.

COST AND PROFIT IN THE UNION *

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Sept. 1959	18,214,200	70 5	45 2	25 3	30,140,529
Oct.	—	—	—	—	—
Nov.	—	—	—	—	—
Dec.	17,670,000	72 2	45 10	26 4	30,559,937
Jan., 1960	—	—	—	—	—
Feb.	—	—	—	—	—
Mar.	17,464,400	72 8	46 5	26 3	30,105,571
April	—	—	—	—	—
May	—	—	—	—	—
June	17,968,300	73 9	46 3	27 6	31,941,743
July	—	—	—	—	—
August	—	—	—	—	—
Sept	18,103,100	74 0	46 4	27 8	32,201,685

* 3 Months.

PRODUCTION OF GOLD IN SOUTH AFRICA

	Rand and O.F.S.	Outside	Total
	Oz.	Oz.	Oz.
January, 1960	1,701,110	34,651	1,735,761
February	1,675,248	38,859	1,714,107
March	1,664,514	38,744	1,703,258
April	1,734,310	36,720	1,771,030
May	1,765,880	37,897	1,803,777
June	1,775,335	37,530	1,812,865
July	1,776,141	39,673	1,815,814
August	1,778,711	36,777	1,815,488
September	1,774,967	35,352	1,810,319
October	1,777,495	35,967	1,813,462
November	1,775,624	36,159	1,811,783
December	1,744,406	34,044	1,778,450

NATIVES EMPLOYED IN THE SOUTH AFRICAN MINES

	Gold Mines	Coal Mines	Total
April 30, 1960	385,841	—	—
May 31	383,212	30,933	414,145
June 30	380,593	31,435	412,028
July 31	378,626	31,879	410,505
August 31	374,303	32,321	406,624
September 30	369,751	32,996	402,747
October 31	368,351	33,387	401,778
November 30	367,658	33,052	400,710
December 31	364,407	32,791	397,198

MISCELLANEOUS METAL OUTPUTS

	4-Week Period To Dec. 31		
	Tons Ore	Lead Concs. tons	Zinc Concs. tons
Broken Hill South	25,300	4,066	4,223
Electrolytic Zinc	14,385	765	4,280
Lake George	17,482	1,334	2,704
Mount Isa Mines**	63,344	3,950†	4,905
New Broken Hill	78,710	7,846	18,934
North Broken Hill	—	—	—
Zinc Corp.	94,140	14,108	18,067
Rhodesia Broken Hill*	—	—	—

* 3 Months, ** Copper 2,750 tons blister; 7,925 tons concs.; † Metal

RHODESIAN GOLD OUTPUTS

	November		December	
	Tons	Oz.	Tons	Oz.
Cam and Motor	—	—	—	—
Falcon Mines	22,500	4,398	22,300	4,360
Globe and Phœnix	6,150	3,168	—	—
Motapa Gold Mining	—	—	—	—
Mazoe	3,028	—	3,079	—
Coronation Syndicate	11,862	—	11,073	—
Phœnix Prince*	—	—	—	—

* 3 Months.

WEST AFRICAN GOLD OUTPUTS

	November		December	
	Tons	Oz.	Tons	Oz.
Amalgamated Banket	51,942	12,044	47,835	10,326
Ariston Gold Mines	40,330	11,154	41,000	11,218
Ashanti Goldfields	57,500	30,000	37,500	30,000
Bibiani	33,000	6,800	35,000	6,700
Bremang	—	3,952	—	4,609
Ghana Main Reef	11,033	4,220	11,405	4,334
Konongo	6,950	3,814	7,200	3,765
Lyndhurst	—	—	—	—

PRODUCTION OF GOLD AND SILVER IN RHODESIA

	1959		1960	
	Gold (oz.)	Silver (oz.)	Gold (oz.)	Silver (oz.)
January	46,489	18,077	44,902	29,711
February	43,366	19,806	45,754	29,865
March	48,397	17,394	45,309	29,656
April	46,315	5,694	48,607	6,847
May	46,423	46,280	47,542	62,912
June	49,995	31,386	45,884	34,298
July	46,512	32,734	44,865	33,323
August	38,727	29,178	48,284	28,931
September	56,760	33,837	48,865	38,951
October	48,528	32,314	—	—
November	47,916	31,092	—	—
December	47,452	31,175	—	—

WESTRALIAN GOLD PRODUCTION

	1958	1959	1960
	Oz.	Oz.	Oz.
January	66,562	63,924	64,794
February	65,965	65,035	66,789
March	65,420	65,408	61,941
April	60,855	62,686	65,373
May	64,196	64,184	66,682
June	67,929	74,590	74,902
July	81,106	78,974	67,623
August	68,610	68,546	67,466
September	68,744	66,501	68,794
October	70,128	70,427	67,310
November	67,562	68,858	107,815
December	120,106	117,474	—
Total	867,187	861,122	—

AUSTRALIAN GOLD OUTPUTS

	4-Week Period			
	To Nov. 8		To Dec. 6	
	Tons	Oz.	Tons	Oz.
Central Norseman	14,137	6,852	14,300	6,174
Gold Mines of Kalgoorlie	41,581	11,545	42,128	10,882
Gt. Boulder Gold Mines*	—	—	—	—
Gt. Western Consolidated	31,873	5,286	34,012	5,482
Lake View and Star*	—	—	—	—
North Kalgurli	28,405	7,390	27,628	6,817
Sons of Gwalia	12,734	2,594	—	—
Mount Morgan	—	5,172	—	4,221

* 3 Months.

ONTARIO GOLD AND SILVER OUTPUT

	Tons Milled	Gold Oz.	Silver Oz.	Value Canad'n $
July, 1959	774,749	221,814	32,172	7,498,030
August	683,819	191,598	29,141	6,428,545
September	754,208	213,772	34,139	7,116,556
October	794,030	227,192	34,733	7,558,567
November	770,437	227,176	35,262	7,600,949
December	775,803	221,377	40,807	7,388,654
January, 1960	778,103	226,856	27,617	7,550,068
February	755,569	222,484	35,003	7,446,848
March	804,309	229,457	37,202	7,646,044
April	779,487	218,393	42,997	7,426,262
May	784,391	225,550	32,174	7,765,153
June	791,488	224,833	49,765	7,756,490
July	779,426	222,179	37,002	7,664,968
August	712,792	202,025	35,722	6,883,254
September	772,984	208,019	29,251	7,114,785
October	805,753	228,914	33,808	7,860,787

MISCELLANEOUS GOLD AND SILVER OUTPUTS

	November		December	
	Tons	Oz.	Tons	Oz.
Clutha River	—	702	—	690
Lampa (Peru)†	—	43,350	—	—
New Guinea Goldfields	3,754	1,418	—	—
Yukon Consol.	—	—	—	—

† Oz. Silver : Copper, 108 tons ; 127 tons.

AUSTRALIAN BASE-METAL OUTPUTS

Period	Concentrate Production (Long Tons)		
	Zinc	Copper (*a*)	Lead
1959	246,693	89,162	305,163
Provisional			
1959—January	12,946	7,744	14,874
February	23,658	8,493	26,361
March	27,377	9,776	30,402
April	82,992	8,142	23,477
May	25,122	9,400	26,832
June	27,786	10,087	29,298
July	17,570	10,351	19,861
August	25,115	9,757	26,247
September	28,671	9,088	29,333
October	—	—	—
November	—	—	—
December	—	—	—

(*a*) includes Cu content of direct smelting ore.

OUTPUTS OF MALAYAN TIN COMPANIES IN LONG TONS OF CONCENTRATES

	Oct.	Nov.	Dec.
Ampat Tin	91½	99	75
Austral Amalgamated	—	—	—
Ayer Hitam	—	—	—
Berjuntai	238½	218	215
Chenderiang	—	—	—
Gopeng Consolidated	—	—	—
Hongkong Tin	—	—	—
Idris Hydraulic	—	—	—
Ipoh	—	—	—
Kampong Lanjut	283½	277	257
Kamunting	147½	139	122
Kent (F.M.S.)	—	—	—
Kepong	—	—	—
Killinghall	—	—	—
Kinta Kellas	—	25½	—
Kramat	52	45½	46
Kuala Kampar	129	126	140
Kuala Lumpur	—	—	—
Kuchai	—	—	—
Larut	17	33	32
Lower Perak	117	52	35
Malayan	—	—	—
Malaysiam	8	7½	7
Pacific Tin Consolidated	—	—	—
Pahang Consolidated	—	—	—
Pengkalen	—	—	—
Petaling Tin	—	—	—
Rahman Hydraulic	28½	26	—
Rambutan	—	—	—
Rantau	64	63	66
Renong	—	—	188*
Selayang	—	—	—
Siamese Tin Syndicate (Malaya)	45	—	43
Southern Kinta	345	325½	309½
Southern Malayan	—	—	—
Southern Tronoh	—	—	—
Sungei Besi	—	—	—
Sungei Kinta	—	—	—
Sungei Way	—	—	—
Taiping Consolidated	—	—	—
Tanjong	—	—	—
Tekka	—	—	—
Temoh	—	—	—
Tongkah Harbour	143	183	128
Tronoh	—	—	—

* 3 Months.

NIGERIAN MINE OUTPUTS

	Oct. Tons	Nov. Tons
Cassiterite	996	—
Columbite	206	—
Felspar	—	—
Gold	76	—
Kaolin	—	—
Lead Ore	—	—
Limestone	25,823	—
Monazite	1	—
Tantalite	1	—
Thorite	—	—
Wolfram	—	—
Zinc	—	—
Zircon	140	—

MISCELLANEOUS TIN COMPANIES' OUTPUTS IN LONG TONS OF CONCENTRATES

	Nov.		Dec.	
	Tin	Columbite	Tin	Columbite
Amalgamated Tin Mines	410	—	381	—
Anglo-Burma Tin*	—	—	—	—
Bangrin	—	—	53	—
Beralt	4	172†	4	173†
Bisichi	58½	40	—	—
Ex-Lands Nigeria	44	—	45	—
Fabulosa	57	—	—	—
Geevor	55	—	57	—
Gold and Base Metal	63	4	—	—
Jantar Nigeria	20	20	27½	37
Jos Tin	10	—	—	—
Kaduna Prospectors	6	—	7	—
Kaduna Syndicate	19	—	20	—
Katu Tin	—	—	42	—
Kefi Tin	—	—	—	—
London Nigerian Mines	—	—	—	—
Mawchi Mines	—	—	—	—
Naraguta Extended	—	—	—	—
Naraguta Karama	7½	—	—	—
Naraguta Tin	—	—	—	—
Ribon Valley (Nigeria)	—	—	—	—
Siamese Tin Syndicate	—	—	101	—
South Bukeru	—	—	—	—
South Crofty	80	—	88	—
Tavoy Tin	—	—	—	—
Tin Fields of Nigeria	—	—	—	—
United Tin Areas of Nigeria	18½	2	—	—

* 3 Months. † Wolfram.

SOUTH AFRICAN MINERAL OUTPUT

October, 1960.

Gold	1,814,214 oz.
Silver	185,204 oz.
Diamonds	396,987 carats.*
Coal	3,615,369 tons.
Copper	(*a*) — tons in matte and copper-gold concentrates. (*b*) 3,673 tons of 98·94%.
Tin	227 tons concs.
Platinum (concentrates, etc.)	—
Platinum (crude)	—
Asbestos	15,155 tons.
Chrome Ore	62,013 tons.
Manganese Ore	116,128 tons.
Lead Concs.	15 tons.

* *September, 1960.*

IMPORTS OF ORES, METALS, ETC., INTO UNITED KINGDOM

		Oct.	Nov.
Iron Ore	tons	1,592,014	1,618,565
Manganese Ore	„	11,236	50,861
Iron and Steel	„	104,487	127,132
Iron Pyrites	„	21,451	17,090
Copper Metal	„	45,496	44,750
Tin Ore	„	4,896	5,894
Tin Metal	„	1	274
Lead	„	19,626	20,004
Zinc Ore and Conc.	„	11,877	9,516
Zinc	„	12,351	18,662
Tungsten Ores	„	632	515
Chrome Ore	„	26,135	31,289
Bauxite	„	37,765	31,816
Antimony Ore and Concs.	„	1,285	1,311
Titanium Ore	„	11,144	30,872
Tantalite/Columbite	„	82	30
Sulphur	„	27,406	44,190
Barytes	„	2,238	1,319
Asbestos	„	17,924	15,412
Magnesite	„	9,783	6,354
Mica	„	637	403
Graphite	„	763	1,435
Mineral Phosphates	„	79,477	124,561
Molybdenum Ore	„	495	613
Silicon	„	374	482
Nickel	cwt.	57,798	57,236
Aluminium	„	418,142	598,807
Mercury	lb.	95,910	171,332
Bismuth	„	43,941	156,954
Cadmium	„	261,964	255,863
Cobalt and Cobalt Alloys	„	429,572	417,037
Selenium	„	35,791	18,715
Petroleum Motor Spirit	1,000 gals.	57,801	72,844
Crude	„	1,034,763	1,125,853

Prices of Chemicals

The figures given below represent the latest available.

		£	s.	d.
Acetic Acid, Glacial	per ton	104	0	0
„ „ 80% Technical	„	90	0	0
Alum, Comml.	„	25	0	0
Aluminium Sulphate	„	16	10	0
Ammonia, Anhydrous	per lb.		1	6
Ammonium Carbonate	per ton	59	0	0
„ Chloride, 98%	„	28	12	6
„ Nitrate	„	36	5	0
Antimony Sulphide, golden	per lb.		4	0
Arsenic, White, 99/100%	per ton	47	10	0
Barium Carbonate 98–99%	„	42	0	0
„ Chloride	„	45	0	0
Barytes (Bleached)	„	20	0	0
Benzene	per gal.		5	2
Bleaching Powder, 35% Cl.	per ton	30	7	6
Borax	„	46	0	0
Boric Acid. Comml.	„	77	0	0
Calcium Carbide	„	40	17	9
„ Chloride, solid, 70/75%	„	13	5	0
Carbolic Acid, crystals	per lb.		1	4
Carbon Bisulphide	per ton	62	10	0
Chromic Acid (ton lots)	per lb.		2	2⅞
Citric Acid	per cwt.	9	17	0
Copper Sulphate	per ton	77	10	0
Creosote Oil (f.o.r. in Bulk)	per gal.		1	2
Cresylic Acid, refined	„		7	10
Hydrochloric Acid 28° Tw.	per carboy		13	6
Hydrofluoric Acid, 59/60%	per lb.		1	1
Iodine	per kilo		17	4
Iron Sulphate	per ton	3	5	0
Lead, Carbonate, white	„	115	5	0
„ Nitrate	„	110	0	0
„ Oxide, Litharge	„	104	5	0
„ Red	„	102	5	0
Lime Acetate, brown	„	40	0	0
Lithopone	„	57	10	0
Magnesite, Calcined	„	20	0	0
„ Raw	„	13	0	0
Magnesium Chloride	„	20	0	0
„ Sulphate, Comml.	„	15	10	0
Methylated Spirit, Industrial, 66 O.P.	per gal.		6	1
Nickel Sulphate	per ton	189	0	0
Nitric Acid, 80° Tw.	„	35	0	0
Oxalic Acid	„	132	0	0
Phosphoric Acid (S.G. 1·750)	per lb.		1	4
Potassium Bichromate	„		1	2½
„ Bromide	„		2	6
„ Carbonate (hydrated)	per ton	72	10	0
„ Chloride	„	21	0	0
„ Iodide	per kilo		19	3
„ Hydrate (Caustic) solid	per ton	92	0	0
„ Nitrate	per cwt.	3	10	0
„ Permanganate	per ton	198	0	0
„ Sulphate, 50%	„	20	13	0
Sal-Ammoniac	„	70	0	0
Sodium Acetate	„	63	0	0
„ Arsenate, 58–60%	„	Nominal		
„ Bicarbonate	„	18	10	0
„ Bichromate	per lb.		1	0
„ Carbonate (Soda Ash) 58%	„	16	0	0
„ Chlorate	„	77	10	0
„ Cyanide	per cwt.	6	18	10
„ Hydrate, 76/77%, solid	per ton	33	0	0
„ Hyposulphite, Comml.	„	35	0	0
„ Nitrate, Comml.	„	Nominal		
„ Phosphate (Dibasic)	„	40	10	0
„ Prussiate	per lb.		1	0½
„ Silicate	per ton	11	10	0
„ Sulphate (Glauber's Salt)	„	12	5	0
„ „ (Salt-Cake)	„	10	0	0
„ Sulphide, flakes, 60/62%	„	38	12	6
„ Sulphite, Comml.	„	27	15	0
Sulphur, American, Rock (Truckload)	„	13	0	0
„ Ground, Crude	„	17	10	0
Sulphuric Acid, 168° Tw.	„	12	0	0
„ „ free from Arsenic, 140° Tw.	„	8	10	0
Superphosphate of Lime, 18% P_2O_5	„	14	18	6
Tin Oxide	„	Nominal		
Titanium Oxide, Rutile	„	172	0	0
„ White, 25%	„	85	0	0
Zinc Chloride	„	95	0	0
„ Dust, 95/97% (4-ton lots)	„	128	0	0
„ Oxide	„	97	10	0
„ Sulphate	„	32	0	0

Share Quotations

Shares of £1 par value except where otherwise stated.

GOLD AND SILVER:	Dec. 8, 1960 £ s. d.	Jan. 10 1961 £ s. d.
SOUTH AFRICA:		
Blinkpoort (5s.)	3 2 6	2 17 6
Blyvooruitzicht (2s. 6d.)	1 11 3	1 9 3
Bracken (10s.)	1 9 6	1 11 6
Brakpan (3d.)	5 0	4 6
Buffelsfontein (10s.)	2 1 6	2 1 6
City Deep	19 0	1 0 6
Consolidated Main Reef	15 0	13 0
Crown Mines (10s.)	1 7 6	1 6 6
Daggafontein (5s.)	1 2 9	1 2 0
Dominion Reefs (5s.)	11 0	13 9
Doornfontein (10s.)	1 7 3	1 8 3
Durban Roodepoort Deep (10s.)	1 16 0	1 15 3
East Champ d'Or (2s. 6d.)	1 9	1 9
East Daggafontein (10s.)	10 9	10 3
East Geduld (4s.)	1 0 0	19 9
East Rand Ext. (5s.)	19 3	18 9
East Rand Proprietary (10s.)	1 18 3	1 18 3
Freddies Consol.	2 0	2 3
Free State Dev. (5s.)	6 9	6 9
Free State Geduld (5s.)	6 8 9	5 17 0
Free State Saaiplaas (10s.)	8 3	9 0
Geduld	3 3 9	2 17 6
Government Gold Mining Areas (3d.)	3 0	2 9
Grootvlei (5s.)	1 1 3	1 1 3
Harmony (5s.)	1 9 6	1 11 0
Hartebeestfontein (10s.)	2 9 0	2 9 6
Libanon (10s.)	15 9	16 6
Loraine (10s.)	1 7 6	1 6 6
Luipaards Vlei (2s.)	7 9	7 3
Marievale (10s.)	1 8 6	1 8 3
Modderfontein B (3d.)	1 6	1 6
Modderfontein East	12 9	11 6
New Kleinfontein	5 3	5 6
New Pioneer (5s.)	1 13 9	1 14 3
New State Areas (15s. 6d.)	9	9
President Brand (5s.)	3 1 3	3 2 3
President Steyn (5s.)	1 2 3	1 1 0
Rand Leases (9s. 3d.)	7 9	7 0
Randfontein	18 0	19 6
Rietfontein (3d.)	3 6	2 9
Robinson Deep (5s. 6d.)	5 0	4 9
Rose Deep (3d.)	7 0	6 0
St. Helena (10s.)	3 19 3	3 19 3
Simmer and Jack (1s. 6d.)	1 6	2 0
South African Land (3s. 6d.)	17 9	16 6
Springs (3d.)	1 9	1 6
Stilfontein (5s.)	1 16 0	1 15 9
Sub Nigel (3d.)	9 6	9 0
Vaal Reefs (5s.)	2 5 6	2 5 0
Van Dyk (3d.)	3 0	2 9
Venterspost (10s.)	1 3 0	1 3 6
Virginia (5s.)	3 9	4 0
Vlakfontein (10s.)	17 6	17 6
Vogelstruisbult (3d.)	5 0	4 9
Welkom (5s.)	16 9	17 9
West Driefontein (10s.)	4 17 6	4 18 9
West Rand Consolidated (10s.)	1 0 0	19 9
West Witwatersrand Areas (2s. 6d.)	3 5 9	3 11 3
Western Holdings (5s.)	7 15 0	7 12 6
Western Reefs (5s.)	1 10 6	1 9 3
Winkelhaak (10s.)	1 7 6	1 7 9
Witwatersrand Nigel (2s. 6d.)	1 0	1 0
Zandpan (10s.)	12 0	12 6
RHODESIA:		
Cam and Motor (2s. 6d.)	—	—
Chicago-Gaika (10s.)	15 0	15 0
Coronation (2s. 6d.)	5 0	5 0
Falcon (5s.)	9 9	9 6
Globe and Phœnix (5s.)	1 12 3	1 11 3
Motapa (5s.)	—	—
GHANA:		
Amalgamated Banket (3s.)	7½	6
Ariston Gold (3s. 6d.)	2 9	2 9
Ashanti Goldfields (4s.)	15 0	15 0
Bibiani (4s.)	2 3	2 3
Bremang Gold Dredging (5s.)	2 3	2 0
Ghana Main Reef (5s.)	1 9	1 6
Konongo (2s.)	1 3	1 3
Kwahu (2s.)	4 6	4 0
Offin River (2s. 6d.)	2 0	2 0
Western Selection (5s.)	3 6	3 6
AUSTRALASIA:		
Gold Fields Aust. Dev. (3s.), W.A.	1 6	1 6
Gold Mines of Kalgoorlie (10s.)	8 0	7 6
Great Boulder Propriet'y (2s.), W.A.	12 3	12 0
Lake View and Star (4s.), W.A.	1 10 0	1 5 0
Mount Morgan (10s.), Q.	13 6	13 0
New Guinea Gold (4s. 3d.)	1 9	1 6
North Kalgurli (1912) (2s.), W.A.	12 0	10 6
Sons of Gwalia (10s.), W.A.	2 9	2 9
Western Mining (5s.), W.A.	9 9	10 9

	Dec. 8, 1960 £ s. d.	Jan. 10, 1961 £ s. d.
MISCELLANEOUS:		
Fresnillo ($1·00)	1 3 9	1 5 3
Kentan Gold Areas	1 0 0	19 3
St. John d'el Rey, Brazil	4 7 6	4 8 6
Yukon Consolidated ($1)	3 11	4 0
COPPER:		
Bancroft Mines (5s.), N. Rhodesia	15 3	15 3
Esperanza (2s. 6d.), Cyprus	1 4½	1 6
Indian (2s.)	4 9	5 3
MTD (Mangula) (5s.)	7 0	7 0
Messina (5s.), Transvaal	16 0	16 6
Mount Lyell (5s.), Tasmania	4 6	4 9
Nchanga Consolidated, N. Rhodesia	2 6 9	2 6 9
Rhokana Corporation, N. Rhodesia	2 5 0	2 5 3
Roan Antelope (5s.), N. Rhodesia	5 3	5 6
Tanganyika Concessions (10s.)	1 7 6	1 6 9
LEAD-ZINC:		
Broken Hill South (1s.), N.S.W.	9 3	9 9
Burma Mines (3s. 6d.)	1 3	1 3
Consol. Zinc Corp. Ord.	3 1 3	3 7 0
Lake George (5s.), N.S.W.	3 9	3 9
Mount Isa, Queensland (5s. Aust.)	2 6 3	2 7 0
New Broken Hill (5s.), N.S.W.	1 19 0	1 19 3
North Broken Hill (10s.), N.S.W.	15 0	15 0
Rhodesia Broken Hill (5s.)	7 3	6 9
San Francisco (10s.), Mexico	16 3	16 9
TIN:		
Amalgamated Tin (5s.), Nigeria	9 6	10 3
Ampat (4s.), Malaya	11 9	11 6
Ayer Hitam (5s.), Malaya	19 0	1 1 9
Beralt (5s.), Portugal	1 10 9	1 12 9
Bisichi (2s. 6d.), Nigeria	5 3	5 0
Ex-Lands (2s.), Nigeria	3 0	3 6
Geevor (5s.), Cornwall	18 6	18 3
Gold Base Metals (2s. 6d.), Nigeria	1 9	1 10½
Hongkong (5s.), Malaya	10 0	9 3
Jantar Nigeria (3s.)	6 9	6 6
Kaduna Syndicate (2s.), Nigeria	2 6	2 6
Kamunting (5s.), Malaya	14 0	14 6
Malayan Tin Dredging (5s.)	1 4 0	1 3 6
Mawchi Mines (4s.), Burma	1 0	1 9
Naraguta Karama (5s.), Nigeria	1 3	1 3
Pahang (5s), Malaya	8 9	9 6
Siamese Synd. (5s.)	10 9	12 3
South Crofty (5s.), Cornwall	4 3	3 10½
Southern Kinta (5s.), Malaya	1 6 0	1 6 3
Southern Malayan (5s.)	18 9	1 0 9
Sungei Besi (4s.), Malaya	1 1 6	1 3 9
Sungei Kinta, Malaya	13 6	15 6
Sungei Way (2s. 4d.), Malaya	3 9	4 3
Temoh (7s. 6d.), Malaya	3 0	2 9
Tronoh (5s.), Malaya	1 13 6	1 18 3
United Tin Areas (2s. 6d.), Nigeria	2 0	1 10½
DIAMONDS:		
Anglo American Investment	12 5 0	12 10 0
Consol African Selection Trust (5s.)	1 0 9	15 6
Consolidated of S.W.A. Pref. (10s.)	10 6	10 0
De Beers Deferred (5s.)	7 8 3	7 15 6
FINANCE, Etc.		
African & European (10s.)	3 7 6	3 5 0
Anglo American Corporation (10s.)	8 5 9	8 5 0
Anglo Transvaal 'A' (5s.)	1 17 6	1 17 6
British South Africa (15s.)	3 8 9	3 8 9
British Tin Investment (10s.)	1 8 0	1 11 6
Broken Hill Proprietary	3 11 0	2 10 9
Camp Bird (10s.)	9 0	7 9
Central Mining	3 19 3	3 17 0
Central Provinces Manganese (10s.)	1 4 3	1 3 9
Consolidated Gold Fields	3 8 6	3 3 9
Consolidated Mines Selection (10s.)	1 14 0	1 13 0
Corner House	16 3	15 3
East Rand Consolidated (5s.)	2 0	2 0
Free State Development (5s.)	6 9	6 9
General Exploration O.F.S. (2s. 6d.)	4 0	4 3
General Mining and Finance	5 7 6	5 1 3
Hendersons (4s.)	9 6	9 0
Johannesburg Consolidated	2 12 9	2 12 0
London & Rhod. M. & L. (5s.)	4 6	4 6
London Tin Corporation (4s.)	12 0	13 3
Lydenburg Est. (5s.)	16 0	14 6
Marsman Investments (10s.)	2 9	2 9
National Mining	2 0	2 0
Rand Mines (5s.)	4 11 3	4 8 9
Rand Selection (5s.)	3 0 9	2 5 6
Rhodesian Anglo American (10s.)	2 17 0	2 19 0
Rhodesian Corporation (5s.)	2 3	2 3
Rhodesian Selection Trust (5s.)	9 3	9 6
Rio Tinto (10s.)	1 11 0	1 16 3
Selection Trust (10s.)	4 6 0	4 6 3
South West Africa Co. (3s. 4d.)	10 0	10 0
Union Corporation (2s. 6d.)	3 5 6	3 7 0
Vereeniging	5 7 6	5 8 9
West Rand Inv. Trust (10s.)	2 17 6	3 0 3

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section abstracts of important articles and papers appearing in technical journals and proceedings of societies are given, together with brief records of other articles and papers; also notices of new books and pamphlets and lists of patents on mining and metallurgical subjects.

Isotopic Tracers in Metallurgical Research

Report of Investigations 5689 of the United States Bureau of Mines, by H. L. Gibbs, C. H. Schack, and J. B. Clemmer, discusses "Applications of Radioisotopes in Metallurgical Research." The first part of the report deals with licensing requirements in the U.S.A. for the purchase of isotopes, with the facilities required in a radiochemical laboratory in view of the hazards of exposure to radiation, and then with instruments and methods. The authors then go on to say that the report gives major attention to the utilization of a variety of radioisotopes in extractive metallurgy and to analytical research on beryllium, cesium, lithium, rubidium, tungsten, scandium, nickel, cobalt, tellurium, and selenium-bearing ores and materials. Intermittent study has been given to employment of the natural radioactivity of uranium- and thorium-bearing ores for monitoring and controlling the operation of a continuous test plant. Some pioneering research also has been undertaken to activate minerals, metals, and compounds in low and high neutron fluxes, to tag specific minerals with selected radioisotopes by chemical and physical absorption methods, and to explore the feasibility of using radioisotopes that emit only weak alpha and beta rays or positrons.

Techniques were devised for monitoring the pressure leaching, countercurrent washing, and solvent extraction operations in the pilot-plant processing of uranium ores. A gamma-sensitive Geiger tube and ratemeter were used to sense and control the pulp level in the autoclave by counting the gamma rays emitted from the pulp through the steel shell of the reactor. Similarly the rise and fall of the liquid-solid interface in the thickeners of the countercurrent decantation washing circuit was monitored by immersing beta-ray counting tubes in the thickeners. By using a liquid-flow beta-counting tube the concentration of daughter elements of uranium discarded in the solvent-extraction plant raffinate were determined. A change in the level of radioactivity reflected either overloading or underloading of the solvent-extraction unit.

Preliminary work was done on developing methods for the continuous measurement and control of pulp flow and density in metallurgical operations. Different radioactive sources were tried for beaming gamma rays through pulp streams. The unabsorbed activity served as an index of the changes in the volume and density of pulp flowing past the counting tube. Tests of gamma rays of different energies led to the discovery that soft gamma rays of intermediate or low penetrating power might be able to solve this problem.

An important accomplishment of the radioactivity research, it is considered, was the development of laboratory techniques, procedures, and counting methods for the effective use of a variety of radioisotopes in hydrometallurgy and pyrometallurgy research. Radioisotopes of beryllium, scandium, cobalt, nickel, iron, aluminium, sodium, selenium, tellurium, rubidium, and cesium were successfully used to study reaction rates, define the effectiveness of alternative processing conditions, and identify trends and anomalies.

Typical Applications

A significant saving in time was achieved in research to develop an improved technology for recovering beryllium from low-tenor and complex concentrates by the use of radioactive beryllium. A crucial step in the beryllium extraction process involved the concentration, purification, and separation of the beryllium from a sulphuric acid leach solution contaminated with large amounts of aluminium and iron. By adding a known quantity of radioactive Be to the pregnant leach solution deportment of all the beryllium was followed through the refining steps by fast radiometric methods. In a typical series of experiments employing solvent extraction techniques for the separation and recovery of beryllium, eight tests were made to determine the loading and stripping characteristics of a particular extractant under different conditions. The tests were completed and the results available to the researcher within 4 hours, whereas 2 or 3 days would have been required had conventional analytical methods been employed. As the results of each test were quickly available each subsequent test could be better planned to establish trends and define anomalies.

Many available radioisotopes emit detectable rays at an extremely rapid rate. The specific activity of Co^{60}, for example, is 370,000 disintegrations a second per microgram. of the isotope. This high activity of the cobalt isotope has been utilized with impressive results in solvent-extraction research to produce cobalt-free nickel from a chloride solution. Prior research on this problem was seriously hampered by the slowness and inadequacy of conventional analytical methods for the determination of cobalt in the range of less than 10 parts cobalt per million parts of nickel. The use of Co^{60} as a tracer permitted use of fast radiometric methods for the quantitative determination of as little as 1 part cobalt per million parts of nickel. Indications are that further research could increase the sensitivity to parts per billion.

Extractive metallurgy on many of the uncommon metals and elements heretofore has been hindered by lack of reliable methods for analysing the raw materials and test products. Using radioisotopes of these elements as tracers and adopting radiometric methods for quantifying and guiding research have eliminated many of the barriers to effective work on the rare and unusual elements. Developing a method for separating, concentrating, and recovering a scandium by-product from waste solutions derived from processing uranium is a typical problem. Progress was virtually non-existent until Sc^{46}, a strong gamma ray emitter, was employed.

The use of radioisotopes has facilitated the study of the equilibrium and reaction rates of several complex chemical systems. The application of radioisotopes to this kind of problem is exemplified by the use of Na^{22}, Rb^{86}, and Cs^{134} in ion exchange, dialysis, and solvent extraction research to develop a process for separating these alkali elements from one another. The deportment of each of the three elements, tagged with their respective isotope, was readily followed through the various processing steps by determining the characteristic photopeak of the gamma-emitting isotope with a spectrogammeometer.

Radioisotopes can be effectively used in pyrometallurgical as well as hydrometallurgical and mineral-dressing research. The radioactive isotope of selenium, Se^{75}, was successfully employed in volatilization research on low-tenor ores. Preliminary tests indicated that whereas over 90% of the selenium was volatilized from the ore only 60% was accounted for in the test products when using conventional assaying methods. By tagging the ore with a small addition of Se^{75} deportment of the selenium in the furnace and in the multiple-stage dust- and fume-collection system was followed accurately by radiometric methods. The "lost" selenium was found as minute deposits of elemental selenium, which had precipitated in cold spots in the furnace and in the ducts connecting the furnace and fume-collection units. All the selenium was located and the tracer techniques permitted continuous monitoring of the reactions involved to establish the crucial reaction rates.

Investigation of the volatilization and recovery of tellurium from low-tenor gold ores was expedited by employing tracer techniques. The tellurium used as a tracer was prepared from a sample of high-purity tellurium that had been irradiated for 18 hours at a high-neutron flux in the Materials Test Reactor at Arco, Idaho. The irradiated tellurium was dissolved in nitric acid to give a stock solution for storage. A quantitative check showed that the stock solution was far more radioactive than had been anticipated. A spectrogammeometer analysis revealed the presence of I^{131}, resulting from beta decay of Te^{131}, which accounted for over 90% of the total activity. The radioactive iodine was subsequently removed from the stock solution by distillation. The purified tellurium solution, which contained radioactive Te^{121}, Te^{123}, Te^{125}, and Te^{127}, had sufficient activity and half life for about 3 months of use in metallurgical research. A small amount of the mixture of tellurium isotopes, when thoroughly mixed with the tellurium-bearing ore, permitted monitoring of the volatilization experiments to define the reaction rate and to assay the fume, dust, and furnace-residue products with speed and precision.

Experience has shown that radioisotopes and radiometric methods also have many useful applications in analytical research. Sc^{46}, Rb^{86}, Te^{123}, and Cs^{134} have been used to trace the deportment of these elements through several digestion, precipitation, filtration, and washing steps involved in the quantitative analysis of these elements by chemical, flame photometry, and spectrographic methods. Tracer techniques also have been used in the analytical research undertaken to develop a reliable procedure for the quantitative determination of trace impurities in high-purity tungsten. The method involves the dissolution of a large sample of metal and the precipitation of the dozen or more impurities present as a bulk product. This precipitate is filtered, washed, and redigested and reprecipitated several times to insure that most of the tungsten is eliminated. The purified bulk precipitate is separated into groups of elements, which can be quantitatively assayed by spectrographic methods. The crucial problem is to insure that all impurities are recovered during the several precipitation, dissolution, and separation steps in the procedure. Radioisotopes of the major impurities expected in the tungsten were added singly or in different combinations to the solution prepared from the metal. Radiometric methods were employed to trace the individual impurity elements and determine their response to different conditions.

Planned Research

Not all the elements in the periodic table have radioisotopes that emit easily-detectable gamma rays and have a sufficiently long half life to permit their effective use in metallurgical research. The isotopes of many elements emit gamma, beta, and alpha rays, that are relatively weak and difficult to detect. A promising area now under consideration for expanding the use of radioactivity in research is the development of techniques for employing weak alpha, beta, and gamma emitters. Special methods and techniques will be necessary in the research because of the low penetrating power of the rays and the low rate of emission as compared with the strong gamma emitters.

Many problems in mineral dressing extractive metallurgy and analytical chemistry may be profitably investigated by radioactivity techniques. The contemplated programme at Salt Lake City encompasses basic and applied research in these fields. The chief long-range investigations scheduled include :

(1) Development of methods to continuously measure and control the pulp flows and densities in mineral-dressing and metallurgical pilot plants using beamed soft gamma rays.

(2) Continuation of research directed toward tagging specific minerals with radioisotopes, so that the deportment of these minerals can be accurately followed in milling and metallurgical operations.

(3) Development of techniques employing radioisotopes and radiometric methods to devise faster and better methods for analysing trace elements in high-purity metals and quantitatively analysing rare and uncommon elements.

(4) Investigation of the feasibility of employing low- and high-neutron and gamma flux reactors for irradiating minerals, metals, and compounds for metallurgical research.

(5) A study of the effects of radiation and particle bombardment on the rates and mechanisms of metallurgical and chemical reactions.

Skip Hoist at a Nevada Open-Pit

The use of a skip hoist to move ore from the lower levels of the Liberty Pit of the Kennecott Copper Corporation at Ruth, Nevada, is described in the *Mining World* of San Francisco for December last. It is stated that, installed at a cost of about $1,500,000, the new hoist speeds 25 tons of copper ore out of the mine in about a minute, as compared to 10 to 15 min. by truck. Completed in June, 1959, the skip hoist carries more than 12,600 tons of ore a day out of the pit—or approximately 60% of daily ore production. The balance is still hauled from the upper benches by trucks.

The skip is located in the middle of the north side of the pit which has an overall slope of 23°, the skip slope being 19° 04′. The trackway for the skip system from the loading point to the dumping point is 1,234 ft. long with a vertical raise of 405 ft. to the top of the head-frame. The loading station at the bottom is on the 6,704 level of the pit and provisions have been made to extend the skip deeper if needed. The railway consists of two parallel tracks of 90-lb. rails laid on 14-ft. wooden sleepers placed at 2½-ft. intervals, with each fourth tie 18 ft. long. Non-slip tie plates are placed between the rail and ties, which are ballasted and secured with pins into the ground. The two skip cables are supported by rubber-covered rollers placed on 25-ft. centres. Inspection of the track and rollers is facilitated by a walkway running along the side.

Two 25-ton skips weigh 39,490 lb. each and consist of a double-wall welded body resting on a four-wheel open-frame chassis. To provide cushioning the wheels are spring-mounted and the rear axle will pivot, giving three-point suspension. Thus the skips can travel at high speed without danger of derailment. The body of each skip is suspended within the chassis by means of trunnions at approximately the centre of gravity of the load so that dumping of the skip is merely a rocking action of the body within the chassis. At the head-frame the skips are dumped by means of scrolls on dump plates above the storage bins. An automatic slow-down control serving the system allows the skip to enter the scrolls at a speed of only 190 ft. per minute. The hoist pulls the skip through the scroll to tip the body, dump the load, and stop. The two skips operate in counterbalance.

The steel headframe of the system is located on the edge of the pit on the 7,033-ft. level. It contains two separate storage bins each with a level capacity of 100 tons and a surge capacity of 180 tons and each serviced by a standard-gauge railroad track for railway car loading. Each track is equipped with guard rails so truck loading can be accomplished on top of them. The skips dump directly into the storage bins. There are four 7-ft. reciprocating plate feeders, two under each bin, that service the bins and feed the railway cars or trucks. The feeders are hydraulically operated from a special booth at the headframe, as are drop gates that direct the skip loads into the storage bin that is in use at the time of car or truck loading.

The loading structure at the bottom of the skip installation is of the drive-over type with two 25-ton surge bins. These bins are equipped at the top each with double bridge gates and at the bottom each with a skip loading gate. Both types of gates are hydraulically operated. The loading operator opens one of the two bridge gates after a truck has driven over it and the truck dumps directly into the surge bin. The operator then opens the unloading gate which loads the skip. After filling the skip he sends it on its way. This entire hoisting operation is semi-automatic, with a control panel located in a special booth on the side of the loading structure.

Communications between the skip loading operator at the bottom and the car loading operator in the headframe at the top are maintained by means of an intercommunication system.

The hoist is a double-drum cylindrical model with an expanding toggle type clutch coupling the two drums. Each drum is 11 ft. in diameter with an 8-ft. width, grooved for 1⅞-in. hoisting cable. Each drum is mounted on a separate drum shaft, the drum shafts being connected by means of the toggle clutch located between the drums. The clutch housing supports one end of each drum shaft on anti-friction bearing. The other end of the drum shafts each extend into and are supported by a standard twin-pinion gear reducer on anti-friction bearings. The gear reducers are double reduction and have two input pinions coupled to direct-current motors. The gear ratio is approximately 24 to 1. The drive proper is a variable-voltage direct-current system employing four 300-h.p. motors in a single series loop with two 500-kW. generators. These generators are driven by a single 1,250-h.p. leading power factor synchronous motor. Power for this motor is received from one of four secondary feeders at the pit 2,500-kVA 2,300-V. substation.

Braking of the skips is accomplished automatically by two methods in two steps. Slow-down is accomplished by electrical regenerative braking and stopping is accomplished when the skips have reached approximately 5% of full speed by means of electro-magnetic spring-set mechanical brakes acting on drums carried on the reducer side of each of the motor couplings. Each of the mechanical brakes affords 4,000 lb. torque through solenoids when the hoist is decelerated to approximately 5% of speed.

The skip loading operator at the bottom of the incline controls the movement and dumping of haulage trucks at the loading station with signal lights. The loading of the skip is hydraulically controlled and the hoisting and automatic dumping of the skips is done by the same man using push-button controls.

The skips are at present served by seven 22-ton Euclid end-dump trucks that are loaded on the lower levels of the pit by 4-yd. electric shovels.

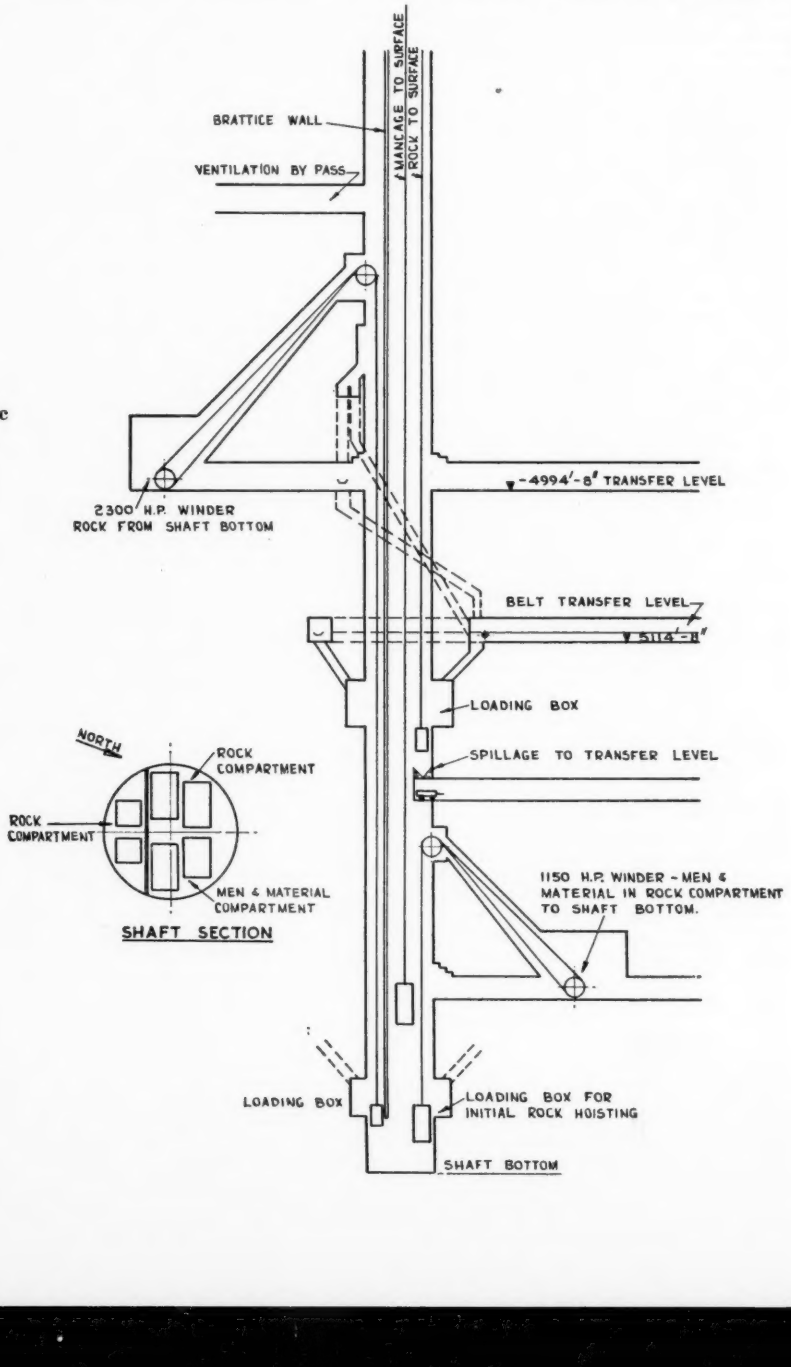
The maximum carrying capacity of the skip system is 1,120 tons per hr. based on a 47-min. operating hr. The total cycle time is 65 sec.—12 sec. for acceleration, 10 sec. for retarding, and 7 sec. rest. The rope speed is 1,630 ft. per min.

At the headframe the bin level indicators at each bin automatically shut the hoist off when the bins are fully loaded. The car loader operator controls the storage bin drop gates and feeders by means of push-button controls. Ore is loaded into the 75-ton railroad cars in a little over a minute for shipment to the Kennecott reduction plant at McGill, some 22 miles distant.

Development at Zandpan

An article in the *South African Mining and Engineering Journal* for November 25 last discusses "Vaal Reef Prospects at Zandpan Gold Mine." The article says that the lease area of Zandpan was extensively drilled before a decision was taken to go ahead with opening it up, the mineralization pattern that emerged closely resembling that obtained in the drilling alone on the Vaal Reef Horizon being exploited by the four existing producers—Buffelsfontein, Hartebeestfontein, Stilfontein, and Vaal Reefs. In 1957 Mr. S. G. Menell, chairman of the Anglo Transvaal group, referring to

Diagrammatic Shaft Layout.



the Zandpan area, said: "The remakarble consistency of the Vaal reef as a carrier of payable gold has been already demonstrated in the development results of the neighbouring mines."

Localized variations in mineralization have been encountered on individual properties—the below-average values met with at Stilfontein between the Charles and Margaret shafts and in initial development around No. 2 shaft at Hartebeestfontein. Nevertheless these have not affected to any extent the profitability of operations of individual mines or the field as a whole. Working costs per oz. for the first nine months of this year ranged from 141s. 6d. and 145s. 6d. There are grounds for expecting that the Zandpan area will fit into the pattern that has been established—consistent mineralization with a relatively high percentage payability.

Apart from a small area in the south-eastern section of the property and that along the fault and sub-outcrop on the western and northern boundaries of the lease area borehole results point to the existence of well-developed Vaal reef around 7,000 ft. from the surface. A clearer picture of what may be expected in the way of mineralization should come as Hartebeestfontein extends its development on reef westwards. So far this has been showing improving values and one startling borehole result was obtained. (Recent values in borehole TL 45, about 4,800 ft. west of No. 1 shaft, show the Vaal reef at 6,608 ft. to have a value of 4 dwt.; at 6,599 ft. a leader reef gave 330 in.-dwt. Two deflections to this hole were made, the first giving 24 in.-dwt. on the Vaal reef and 389 in.-dwt. on the leader. The second gave 73 in.-dwt. on the Vaal reef and 440 in.-dwt. on the leader.)

Shaft System

The initial step in opening up the property is the sinking of the No. 1 shaft to a depth of 7,500 ft. (though it may be deepened at a later stage, depending on what reef development shows up) intersecting the Vaal reef horizon at around 7,000 ft. The shaft has a lined diameter of 26 ft. with a brattice wall dividing it to provide upcast and downcast ventilation. This will allow of a quick breakaway with development once the shaft is in commission.

It was originally estimated that this would take place some time in March, 1962, but the steady rate of progress maintained—over 400 ft. a month—suggests that the reef will be intersected about half-way through the first quarter of 1961 and the task completed in a little over a month thereafter. The original plan was to sink the shaft to around 5,000 ft. and continue with a sub-vertical. This was changed to a one-lift shaft, but now a new innovation, for South Africa at any rate, is the installation of sub-vertical hoists at 5,000 ft. for rock hoisting. This should provide considerable economies when the mine comes to production. As can be seen from the shaft section in the accompanying diagram there will be two rock compartments, one on either side of the brattice wall, with the main cages running in the centre.

At the production stage rock will be loaded from boxes at the shaft bottom into skips in the upcast compartment and hoisted by a 2,300-h.p. winder to approximately 5,000 ft. from surface where it will be tipped and transferred to a loading box feeding the rock skips on the downcast side, which will then be taken to surface. A similar system will be used for the man cages using a 1,150-h.p. winder on the downcast side situated below the rock transfer level. In the early stages this hoist will also handle rock, feeding it to skips operated by the permanent man-cage equipment. The use of this should expedite initial development work.

Eventually a second shaft will be sunk to the north of the existing one and drilling to determine a suitable site is in progress. When this will be necessary depends on the results obtained from No. 1 shaft. Should these indicate that sufficient tonnages can be drawn from the No. 1 shaft system to feed the mill sinking could possibly be postponed until the mine is on a profit-making basis. This being the case the double-entry requirements under the Mining Regulations, if more than 1,000 men are to be employed underground, could be met by a connecting drive through to the Hartebeestfontein No. 4 shaft system.

Trade Paragraphs

British Ropes, Ltd., of Doncaster, from their wire rope advisory and technical service department have issued a booklet on multi-strand non-rotating ropes—their installation, handling, maintenance, and inspection.

Imperial Chemical Industries, Ltd., of Imperial Chemical House, Millbank, London, S.W. 1, have revised their Terylene industrial buyers guide which gives a list of manufacturers of industrial hose, V-belts, conveyor-belts, and fire hose made with this product.

F. Reddaway and Co., Ltd., of St. Anthony's, Newcastle upon Tyne, have compiled a new industrial hose catalogue, which gives illustrations and brief descriptions of wrapped ply, braided, armoured, water delivery, hydraulic, air, steam. shot blast, and other hoses in the range of their manufacture.

Qualter, Hall and Co., Ltd., of P.O. Box No. 8, Barnsley, under the title of "A Handful of History" have produced an illustrated record of 100 years of the company—50 years as a limited company. Among products which are mentioned in this review are steam engines, ram pumps, coal washers, haulage gear, decking plant, tipplers, coal skip winding plant, and mine car control plant.

Stothert and Pitt, Ltd., of Bath, announce that they have entered into an agreement with Ellicott Machine Corporation, of Baltimore, U.S.A., for the manufacture, under licence in the United Kingdom, of dredges and dredging machinery of Ellicott design. At the same time the Ellicott company announce that they will be represented in a sales capacity in the United Kingdom by **John Blackwood Hodge and Co., Ltd.,** of London and Northampton. Ellicott Machine Corporation, established 75 years ago, is exclusively engaged in the designing and building of dredges of all types and sizes.

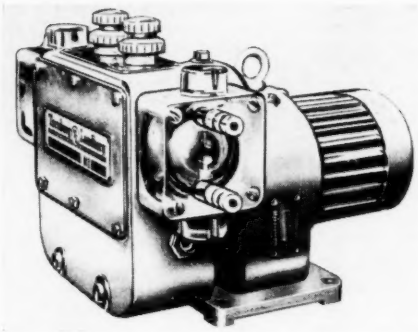
Robello Engineering Co., Ltd., of 43, Dover Street, London, W. 1, call attention to their ball-bearing slewing ring which supports the tilting beam of a travelling tippler, as illustrated. The tippler, which is made by J. Pohlig A.G., of Cologne, is capable of discharging wagons up to 40 tons in weight.

G. A. Harvey and Co. (London), Ltd., of Woolwich Road, London, S.E. 7, have recently opened a sales department and showroom at Villiers House, Strand, London, W.C. 2. The company published last month a 16-page brochure entitled " The Harvey Team " which in addition to giving an outline of the activities and products of the organization contains portraits of the directors and other senior executives and sales staff.

Allen West and Co., Ltd., of Brighton, in an advance statement announce that their electric motor control will be among the special exhibits at the British Trade Fair in Moscow next summer. This, the largest foreign fair yet to be held in the Soviet Union, will occupy a 23-acre site in Moscow's Sokolniki Park of Culture and Rest and will last from May 19 to June 4. The company's equipment will include, in the standard starter range, the PSC4D plug-in unit and a number of flameproof exhibits, including a direct-switching starter, pushbutton stations, and a shunt limit switch as well as other equipment extensively used in the oil-refining, mining and chemical industries.

Nordberg Manufacturing Co., of Milwaukee, Wisconsin, have issued a new 21-page handbook which has been prepared to aid users of Symons cone-crushers in securing the best possible performance and maximum efficiency from these machines. The handbook discusses some of the common problems and faults encountered in crusher operation and bad crushing practices and good crushing practices are outlined with the help of installation photographs. Items included are: Ratio of reduction, feed, selection of crushing members, crusher speed, countershaft adjustment, lubrication, cold weather operation, crushing hot materials, and periods of inspection.

Neldco Processes, Ltd., of Crossway House, Bracknell, Berks, state that the Tolu Feeder is now available in England (see figure) for the first time



for feeding liquids of various kinds under pressure. The feeder is available in single or double units, the capacity of each being from ½ to 7 gal. per hour. The flow can be varied within close limits while the pump is running and each unit is entirely independent. Plexiglass housings and stainless-steel parts are standard, but other materials can be used for special applications. Maximum working pressure is 70 p.s.i. It is made by Aktiebolaget Tolu, of Tunnelgatan 20A, Stockholm, Sweden, and is fully described in an illustrated leaflet.

Saunders Valve Co., Ltd., of Cwmbran, Newport, Mon, announce that they are negotiating with the Netherlands Authorities for the establishment of a branch of business in Leeuwarden, Friesland. The premises to be built will have initially a floor area of 10,000 sq. ft. and provide warehouse and assembly facilities and eventually production of certain lines. The purpose of the new venture is to provide improved service to the company's ever-increasing outlets in the European Common Market. This decision will in no way affect the level of employment at the company's Head Office and principal works in Cwmbran and Newport, Monmouthshire. Further developments to increase production at both these factories are under consideration.

Pohlig Wagon Tippler.

Caterpillar Wheeled Loader 922A.

Thomas Smith and Sons (Rodley), Ltd., of Leeds, have introduced a major improvement to their "21" excavators and crawler cranes. This takes the form of a redesigned track pad of 30 in. width, to effect a reduction in track pin, track lug, and tumbler wear. As a result adjustment of track tension will be required less frequently. The pad has a multi-lug hinge providing 250% more bearing area, as well as being more rigid, and incorporates a design feature which eliminates any form of jerky travel action. If necessary the new track may be plated-in on the top-side, in order to shoot off any loose material which may be dropped from the tracks instead of carrying it round in the ribs of the pad. The Smith "21" excavator is a ¾-cu. yd. machine.

Sandvik Swedish Steels, Ltd., of Halesowen, Birmingham, last month opened their new distribution depot at East Kilbride, near Glasgow. This new venture represents what is believed to be the first operation in Scotland, directly or indirectly, by any Swedish company. Sandvik Swedish Steels, Ltd., have been operating in the United Kingdom since 1868, when the parent organization, the Sandvik Steel Works at Sandviken, Sweden, first established their representation in the British Isles. The premises are situated at Blackbraes Road, Nerston Industrial Area. A wide variety of Sandvik specialities will be stocked especially Coromant tungsten carbide tipped tools and the T-Max throw-away tooling range, as well as mechanical tubing, stainless-steel strip, steel wire, and steel tubes.

Perkins Gas Turbines, Ltd., a subsidiary of F. Perkins, Ltd., of Peterborough, is now marketing the latest U.S.-built Solar gas turbine—the 1,250-h.p. Saturn, suitable for many industrial applications and available in both constant and variable-speed versions. A direct drive of 20,000 r.p.m. is available from the turbine for use with the latest designs of high-speed air and gas compressors. Reduction gearing can be eliminated to reduce first cost and maintenance. Equipped with push-button starting, it requires no warm-up and reaches full power in a maximum of 40 sec. even after long standby periods and in extreme climatic conditions, varying from below zero to 130° F. It can be operated efficiently on most types of fuel and is rated at 1,250 h.p. for intermittent use and 1,100 h.p. for continuous use. The engine has a thermal efficiency of 23% and a fuel consumption of 0·60–0·63 lb/h.p.-hr.

Head Wrightson and Co., Ltd., of 20, Buckingham Gate, London, S.W. 1, state that a new company, Head Wrightson India, Ltd., is being registered, with headquarters in Calcutta. This will be a wholly-owned subsidiary and will act as a contracting company for the supply, as far as possible from Indian sources, of various types of plant to the designs of the parent company. This, it is stated, is a first step in strengthening the company's participation in India's development; as a further move it is hoped to incorporate a rupee company within the next three years. Head Wrightson has maintained a close link with India for many years and has been responsible for supplying much of the specialist equipment used to-day in India's basic industries. The company is at present playing a major part in the Durgapur Steelworks project and supplying all the ironmaking plant as well as much of the ancillary equipment.

Caterpillar Tractor Co., of Peoria, Illinois, and P.O. Box No. 162, Glasgow, recently announced details of the 922A and 966A wheeled Traxcavators. The new machines are similar in configuration and design to the 944A introduced earlier this year. The bucket lift mechanism is located ahead of the operator's compartment, while the open cockpit design ensures good visibility (see illustration). The rating of the 922A is 80 h.p. and it is available with either a four-cylinder turbo-charged diesel engine or a six-cylinder petrol engine. The diesel engine is a new compact design with excellent power to weight ratio. The standard bucket is 1¼ cu. yd. with

maximum lift of 134 in. At 7-ft. bucket clearance the reach is 40¾ in. Among the attachments available are a side dump and a light material bucket. Power unit of the 966A is a six-cylinder turbocharged diesel engine, rated at 140 h.p. This also is a new design compact engine. A 2¾-cu. yd. bucket is standard. Side dump, light material, and quarry buckets are among the attachments available. The maximum bucket lift is 154½ in.

Buell, Ltd., of 3, St. James's Square, London, S.W. 1, a subsidiary company of Edgar Allen and Co., Ltd., Imperial Steel Works, Sheffield 9, announce that they have been awarded contracts for one complete dust collecting installation for dealing with the flue gases from a rotary kiln processing dolomite and a similar installation from a rotary kiln, dealing with dolomite and serpentine, from the same company. The volume of gases being handled by these plants is 136,000 c.f.m. They are the fourth and fifth installations which the company have completed to the order of the same client, the first two having been in satisfactory operation for over three years. Buell, Ltd., have also received instructions from Head Wrightson Iron and Steel Co., Ltd., for the supply of three rotary drum dryers. which will be manufactured by the parent company in Sheffield and will handle up to 130 tons per hour input of Northamptonshire iron ore.

Wickman, Ltd., of Banner Lane, Coventry, issue some notes in connexion with the shaft-sinking record at the No. 4 Shaft of Hartebeestfontein Gold Mining Co., Ltd., mentioned in the December issue. The holes are drilled with 3¾-in. drifters with steels made up by Wickman S.A. (Pty), Ltd. Because of greater inherent reliability a rubber collar is employed instead of the conventional forged-steel type. Although this raised the possibility of slippage this has been overcome by means of a recent innovation (provisionally patented) designed to minimize fracture of the collar. The company also supplied different grades of tungsten carbide tips to suit the various ground conditions encountered in the course of sinking and also different lengths and gauges of steel. They have organized a special delivery service to the mine for this equipment. During the 31 days of the record sinking 52,000 tons of rock was excavated. Rounds of 106 holes, 8 ft. 8 in. long, were often drilled in as little time as 18 min.

Elcontrol, Ltd., of Wilbury Way, Hitchin, Herts., issue some particulars of a fully-automatic water sampling unit, which is a battery-operated portable set which takes liquid samples at regular intervals from channels, streams, tanks, etc. A separate notice describes further development of automatic weight control equipment making use of load cells. By means of this it is possible to provide automatic level control in relation to any vessel or container that is capable of being supported by a compression load cell or suspended from a suspension load cell. Further, the properties of the material being controlled are no longer relevant to the operation of the equipment. Problems, therefore, of conductivity and specific inductive capacity will not arise. Further, the equipment is designed to give a differential ranging from practically 0–90% of the load concerned and this is easily adjustable at any time on the control unit itself. Once the load cells are in position, therefore, it is unnecessary to mount any electrodes or detecting heads on the vessels and the units can be adjusted at any time to give varying services.

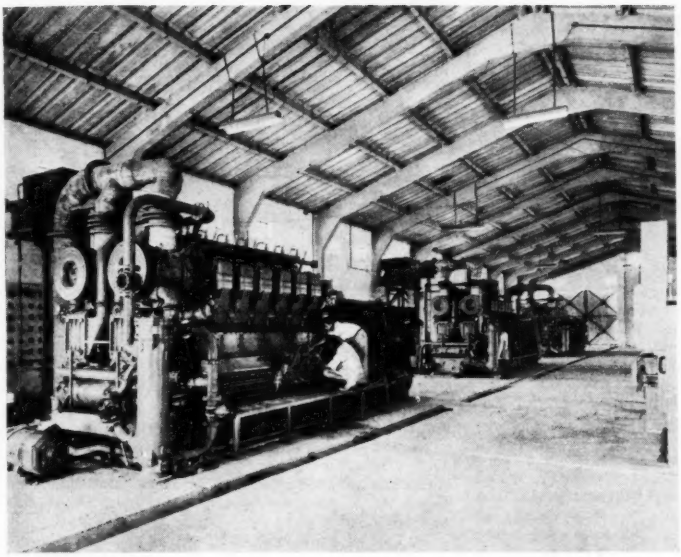
British Geon, Ltd., of Devonshire House, Piccadilly, London, W. 1, announce that Watts Blake and Bearne, Ltd., of Newton Abbot, have recently had the cyclone chimney and hopper of their china-clay pulverizing and drying machine lined in corrosive-resistant PVC paste. Dehydrated particles of clay are forced into the chimney by a blast of hot air and collect there before being released into the hopper for packing. Besides the corrosive effect of sulphur trioxide fumes the chimney has to withstand attack by clay particles and any erosion of the unprotected chimney would contaminate the clay. Natural rubber lining was previously tried, but had to be abandoned because of poor ageing properties. On the other hand, " Vylastic " paste, based on Geon PVC, does not suffer from this disadvantage and provides a coating with excellent corrosive- and abrasion-resistant properties, and good adherence to the substrate metal. At the same time PVC coating has cut costs, for not only is it intrinsically cheaper than rubber lining but, as both internal and external surfaces are coated, it is expected to avoid the need for lagging the chimney, thus achieving a double saving. This was previously necessary to ensure that the temperature inside the chimney did not reach dew point before clay could be packed. The ducting carrying the dried clay to the cyclone chimney is also PVC lined. Coating was carried out by Plastic Coatings, Ltd., of Guildford, Surrey.

Consolidated Pneumatic Tool Co., Ltd., of 232, Dawes Road, Fulham, London, S.W. 6, have introduced a new torque-controlled reversible impact wrench designed for close control of final bolt tightness. This new tool operates as a conventional wrench until the pre-set torque value is reached when the torque control device cuts off the air supply to the motor and the wrench ceases to impact. The required loading is obtained by the operation of a torque adjustment screw located on the handle of the wrench and a lock-out button on either side can be pressed to lock-out the control and allow the wrench to develop its full capacity.

Available in two forms, the CP.610-RLTP wrench is equipped for spline drive while the CP.610-RTP has a 1-in. conventional square drive. The weight of each is 23 lb., the overall length being 16¾ in. The hose size for use with the tool is ½ in. The maximum bolt size when using the lock-out is 1¼ in. and the minimum torque is 300 ft./lb., the maximum being 600 ft./lb.

In a separate notice attention is drawn to a new oil-flooded rotary " Power Vane " compressor of 260 c.f.m. at 100 p.s.i. introduced to meet the demand for a unit between the existing sizes of 210 c.f.m. and 365 c.f.m. The 260-RO-2 is a two-stage in-line compressor powered through a safety friction drive by a six-cylinder Leyland U.E.375 diesel engine. Positive alignment of this engine and the first-stage compression casing is made by a tandem piece which supports the casing and is bolted to the engine flywheel housing, an interstage tandem piece mounting the second stage. The rear end of the second-stage casing is closed by the oil pump housing and cover, a head plate enclosing the front end. To prevent loss of oil and to protect the shaft bearings from dirt a rotary shaft seal is located at the drive end of the compressor.

English Electric Co., Ltd., of English Electric House, Strand, London, W.C. 2, refer in a recent note to two movable substations for open-cast working at a lignite mine near Madras. In the event



English Electric Movable Substation.

of breakdown in the normal supply these substations start automatically and supply power on a ring main system to submersible pumps which keep the mine workings dry. Each substation houses three diesel-alternator sets and associated switchgear (see illustration). The controls of each set are self-contained so that the substations can be moved completely as the face of the mine advances.

Diesel-Alternator Sets.—The six diesel engines, each mounted on an underbed, are of the 12 CSV exhaust turbo-charged type with charge air cooling. Each engine, having a site rating of 1,498 b.h.p. when running at 750 r.p.m., is directly coupled to a 1,037-kW alternator which generates at 11 kV, 3-phase, 50 cycles.

Switchgear.—The six 6-panel switchboards each consist of one exciter control panel, one relay panel for automatic starting, one alternator incomer, one transformer incomer, and two outgoing feeders. The supply is taken by 3-core 11-kV flexible cables, made up from standard lengths with plug and socket connectors for easy lengthening or shortening as required. Each diesel-alternator-switchgear set is complete with its own 110-V battery for control, solenoids, and emergency lighting and a 24-V battery for the 3-h.p. motor-driven lubricating-oil priming pump.

Operation.—In the event of the normal supply from the transformers failing the diesel-alternator sets are started automatically. When they are running at the correct speed and voltage they trip out the transformer breaker and close the alternator breaker. These two breakers are electrically interlocked to prevent parallel operation. Restoration to the normal supply is carried out manually.

General Electric Co., Ltd., from their Engineering Group at Erith, announce that a contract for a winding engine valued at nearly £70,000 has recently been placed with The British General Electric Co. (Pty), Ltd., of South Africa. The winder will be of the double-drum double-clutch type, having cast-steel drums 10 ft. diameter by 4 ft. wide, driven through single-reduction double-helical gears by a single a.c. induction motor. The drum clutches will be of the latest G.E.C. type which is designed to overcome the disadvantages of splined clutches. Provision is made for the fitting at a later date of a spragging arrangement which will provide a positive lock entirely independent of friction to hold the unclutched drum. The a.c. induction motor will be controlled by a weir-type liquid starter and equipment to give the company's patent speed-control feature will also be supplied. The mechanical braking system will consist of two pairs of suspended post brake shoes (one pair per drum), each operated by a standard low-pressure oil-operated brake engine. The mechanical equipment for the winder will be designed by the Erith works and manufactured in South Africa by the East Rand Engineering Co., Ltd. Design and manufacture of the electrical equipment will be carried out at the Witton Works.

A second notice issued by the company refers to an order from the East Rand Engineering Company of Johannesburg for equipment to be used in the conversion of a winder from steam to electric drive. The converted winder will be installed underground at the Withok gold mine of the South African Land and Exploration Co., Ltd., of the Anglo American Corporation. Twin 6·6-kV, 1,150-h.p., 10-pole a.c. motors will be used to drive the 12 ft by 5 ft double-drum winder which will be fitted with G.E.C.'s latest closed-loop a.c. speed-control equipment. An unusual feature of the electrical system is that both rotors are to be connected in parallel to one liquid controller. Switch and control gear are included in the contract.

Firth Cleveland Instruments, Ltd., of Treforest, Glamorgan, state that two types of diaphragm hopper level switches have been developed. They are designed to shut off the flow of granular or semi-solid material into a hopper, bunker, or silo when the level of the material reaches a height

predetermined by the mounting position of the switch. One type consists of an aluminium-alloy housing which is mounted on the wall or sloping floor of the hopper, the inside face being sealed by a strong synthetic-rubber diaphragm. When the material in the hopper presses against this diaphragm its deflection displaces a spring-loaded plunger which in turn actuates a standard single-pole change-over microswitch. The pressure of material against the diaphragm can therefore be arranged to open or close a circuit for alarm or control purposes. The other type is for use in enclosed bunkers where the switch diaphragm may in some cases be exposed to a pressure differing from atmosphere—as, for example, when light materials are conveyed by forced or induced draught and changes in pressure applied to the diaphragm might cause spurious operation of the switch. To enable the switch to distinguish between the pressure of the material and the abnormal air pressure in the hopper the latter is fed also to the back of the diaphragm and so becomes self-balancing. For this purpose the actuating plunger is provided with a seamless metallic bellows seal and the back pressure is fed to the diaphragm through the company's pressure bulb transmitter. The transmitter, which is mounted in the roof of the hopper, contains a synthetic-rubber pressure bulb specially shaped in the form of a piston with a flexible membrane around its periphery. Changes in the pressure in the hopper are faithfully transmitted by the pressure bulb *via* small-bore tubing connecting the transmitter to the back of the diaphragm in the level switch. This arrangement ensures that the operation of the level switch is independent of variations in the temperature of the air in the sealed system due to ambient conditions.

Newton Chambers and Co., Ltd., of Thorncliffe, near Sheffield, in a recent Press statement announce that another order worth 1,500,000 dollars from Canada for an electrically-driven walking dragline to be used for coal stripping, this time in the Maritime Provinces, has been received by **Ransomes and Rapier, Ltd.,** of Ipswich. It may be recalled that Ransomes and Rapier about a year ago obtained an order for a similar machine from Calgary Power, Ltd., of Alberta and that was the first time a contract for such machinery had been placed in Great Britain for delivery to the North American Continent. Work on this machine has reached an advanced stage and shipment will begin early next year. The machine is the RapieR W.1350. It weighs 1,400 tons and is equipped with a 33-cu. yd. bucket capable of carrying 50 tons at a radius of 215 ft. Several of these draglines are employed in the iron-ore fields in Northamptonshire and Lincolnshire and a RapieR W.1800, which will weigh 1,850 tons, have a 303-ft. fabricated boom, and a 20-cu. yd. bucket, is now nearing completion for the United Steel Companies' Ore Mining Branch and will be used at the Roxby open-cast workings near Scunthorpe. One special requirement of the machines now being made for Canada is their suitability for work at very low temperatures. Special steels have, therefore, been used in order to meet such conditions.

The associated company **NCK-Rapier, Ltd.,** recently issued a number of leaflets describing and illustrating some of their range of shovels, draglines, and cranes. Included in these are the 405 machine of 1 cu. yd. (or 1½ cu. yd. as a dragline) which has the usual full range of front-end equipment and the 1205 available with a 2½-cu. yd. or a 3-cu. yd. bucket as a stripper shovel, with a 4-cu. yd. dragline bucket, or as a 62-ton crane or grab crane. The 545 sprawler is a crawler-mounted machine which is equipped with pivoting outriggers so that the operating base becomes square for equal lifts over the side or the end of up to 40 tons. It is also available as a grab crane or a dragline.

RECENT PATENTS PUBLISHED

☛ A copy of the specification of the patents mentioned in this column can be obtained by sending 3s. 6d. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.

11,191 of 1956 (854,461). Mond Nickel Co., Ltd. Reduction of nickel oxide.

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38,918–9 of 1957 (854,855–6). Stamicarbon N.V. Apparatus for separating pieces of solid material into fractions according to specific gravity.

26,243–4 of 1958 (853,272–3). Hayden-Nilos, Ltd. Infusion equipment for shot-firing.

28,213 of 1958 (853,080). Mine and Smelter Supply Co. Conveying and size segregation during crushing.

32,795 of 1958 (853,017). Mineral Processing Corporation. Separation of solids.

36,921 of 1958 (853,522). A. Subervie. Preparation of ores.

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6,511 of 1959 (854,027). General Electric Co. Treatment of scheelite ores.

NEW BOOKS, PAMPHLETS, ETC.

☛ Publications referred to under this heading can be obtained through the Technical Bookshop of *The Mining Magazine*, 482, Salisbury House, London, E.C. 2.

Ultraviolet Guide to Minerals : With Mineral Identification Charts. By Sterling Gleason. Cloth, octavo, 244 pages, illustrated. Price 52s. 6d. Princeton, New Jersey : D. Van Nostrand Company, Inc.

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Selected Index to Current Literature

This section of the Mining Digest is intended to provide a systematic classification of a wide range of articles appearing in the contemporary technical Press, grouped under heads likely to appeal to the specialist.

* Article in the present issue of the MAGAZINE. † Article digested in the MAGAZINE.

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